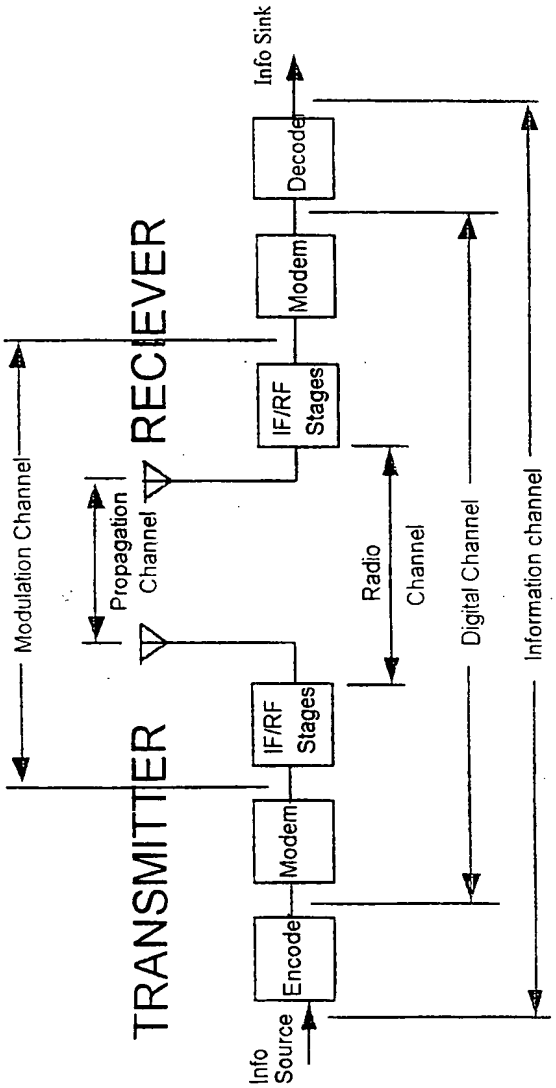


Figure 1: Communications Channel Definitions

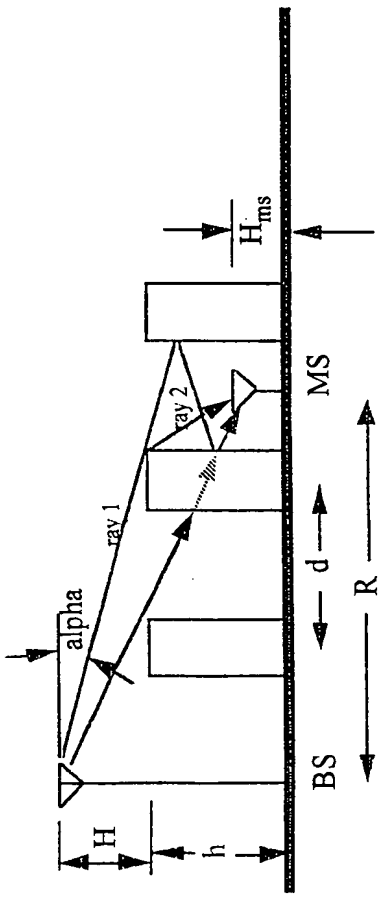


Figure 2: Various ray paths with building presence

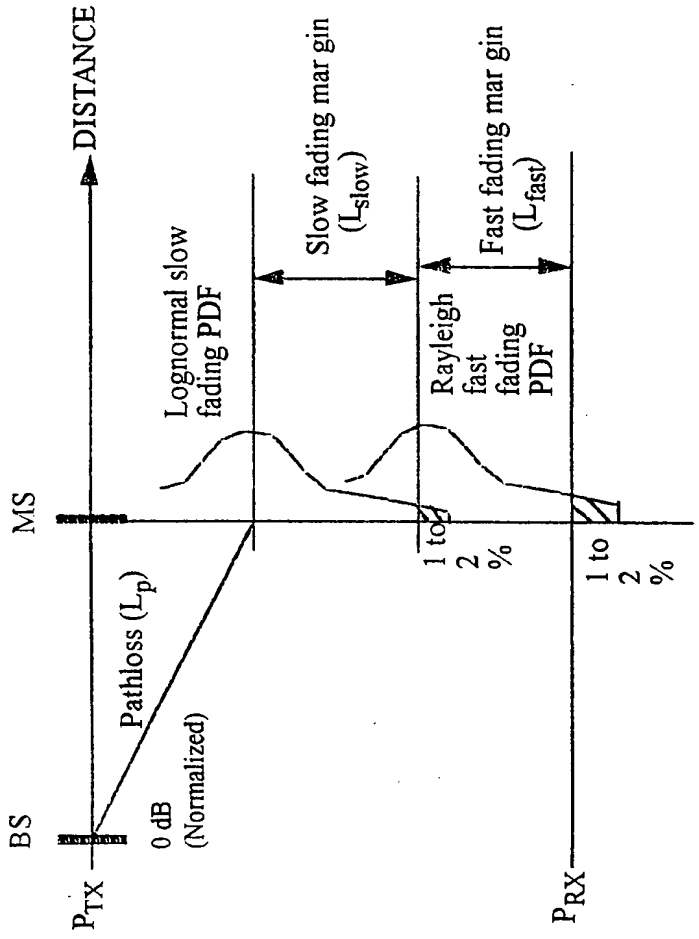


Figure 3: Statistical Power Budget Design

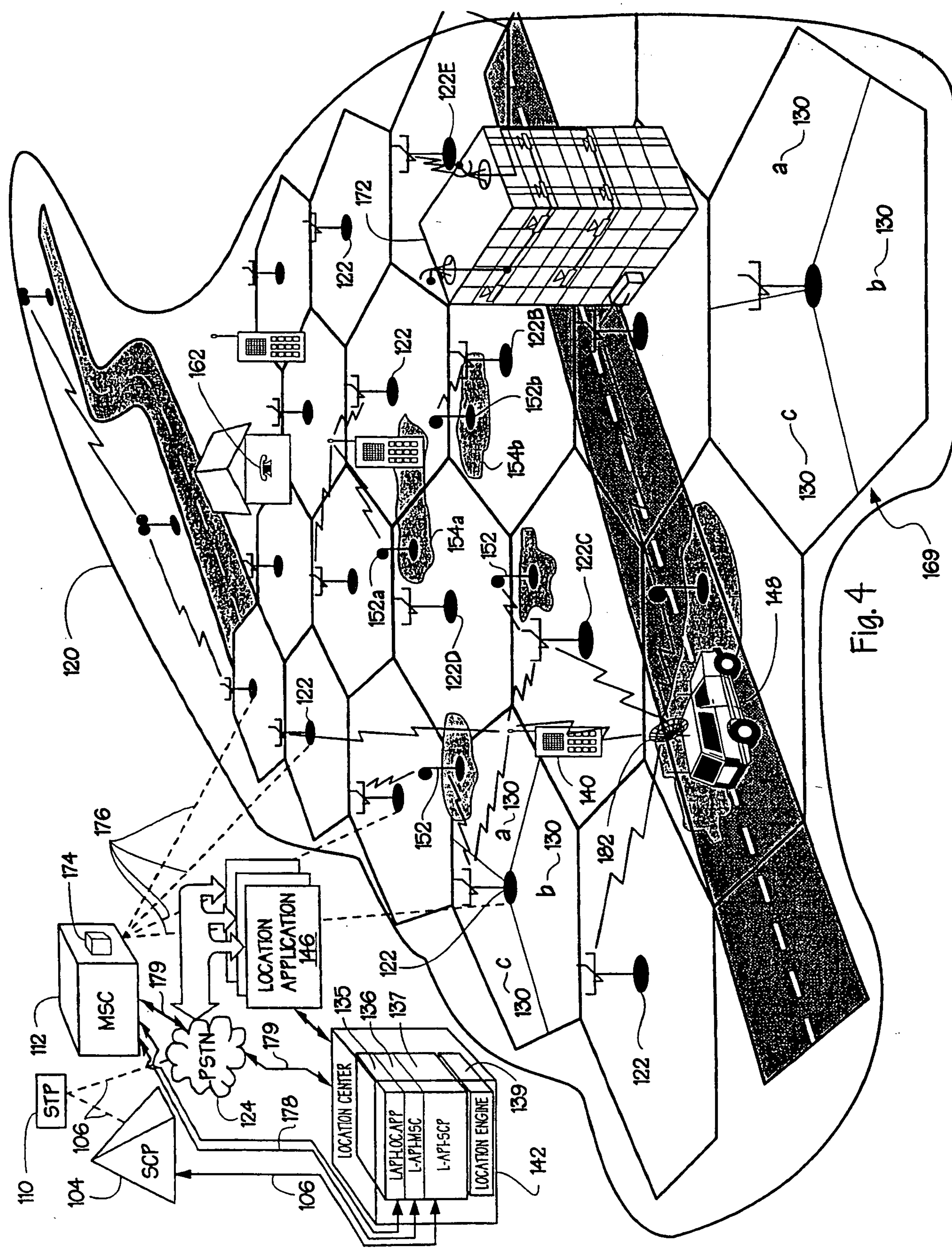


Fig. 4

FIG. 5

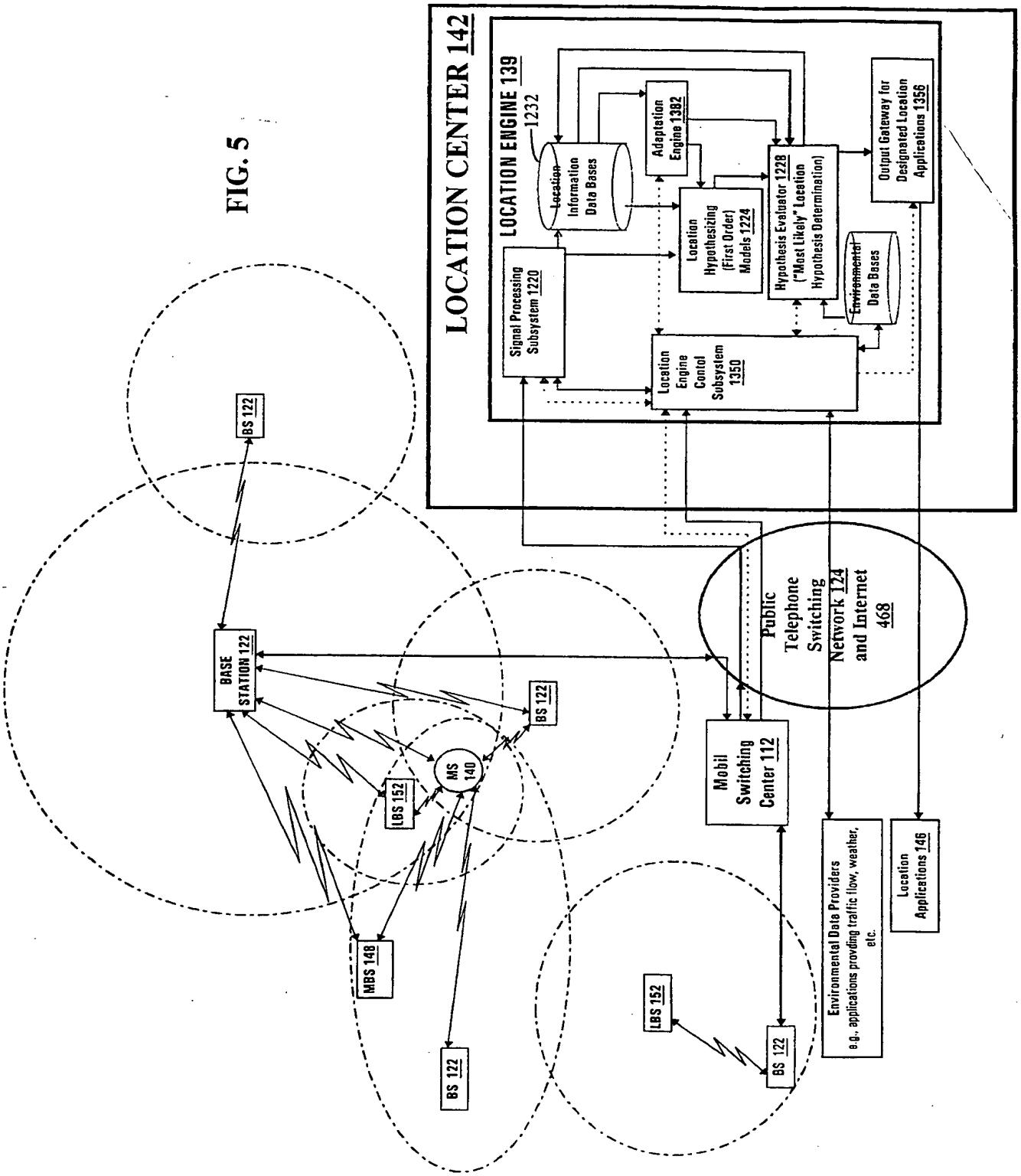
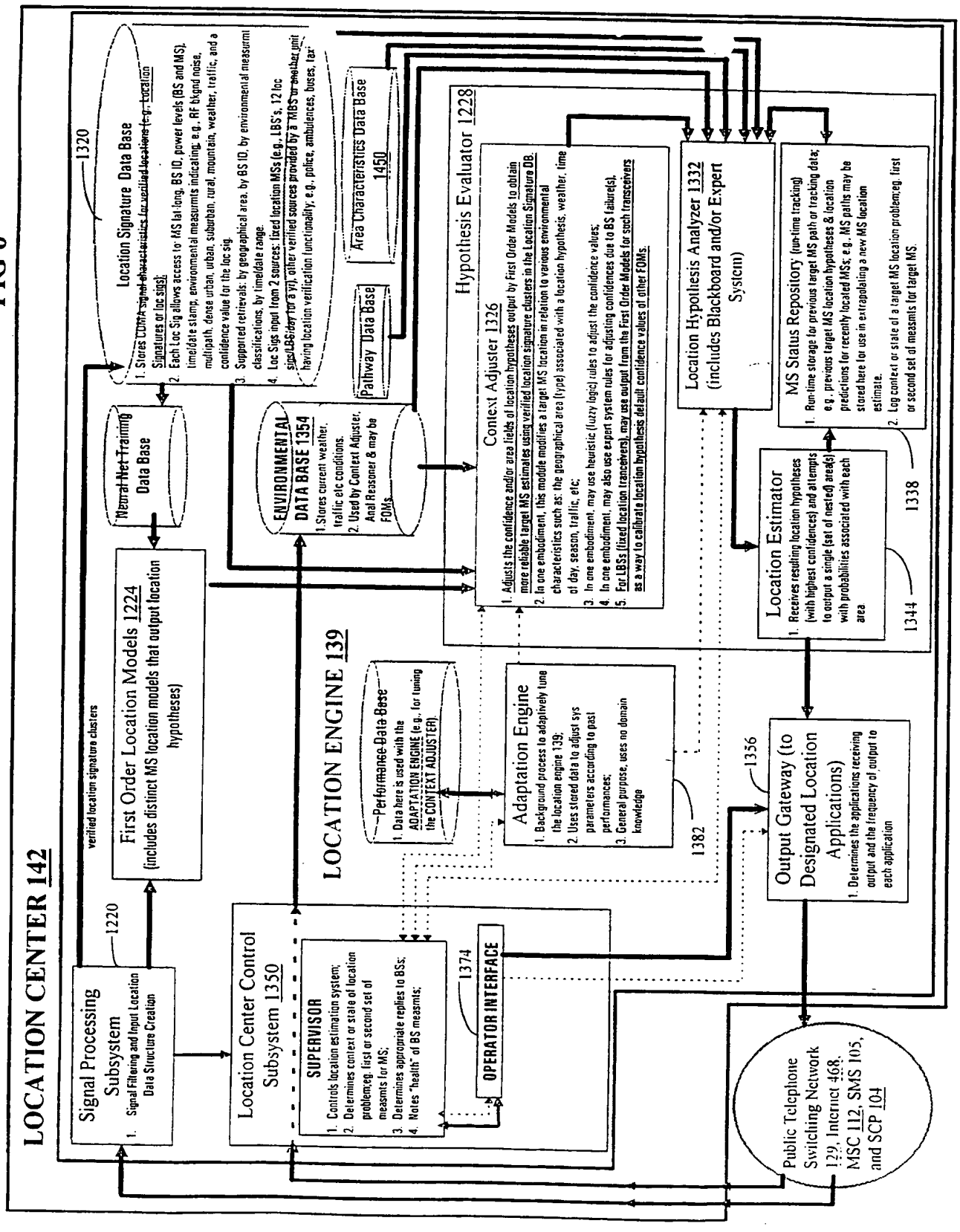

LOCATION CENTER 142
LOCATION ENGINE 139
1232
Location Information Data Bases
Adaptation Engine 1382
Location Hypothesizing (First Order) Models 1224
Hypothesis Evaluator 1228 ("Most Likely" Location Hypothesis Determination)
Output Gateway for Designated Location Applications 1356
Signal Processing Subsystem 1220
Environmental Data Bases
Location Engine Contol Subsystem 1350
Public Telephone Switching Network 124 and Internet 468
Mobil Switching Center 112
Environmental Data Providers e.g., applications providing traffic flow, weather, etc.
Location Applications 146
BASE STATION 122
BS 122
MS 140
LBS 152
MBS 148

FIG 6


LOCATION CENTER 142
Signal Processing Subsystem
1. Signal Filtering and Input Location Data Structure Creation
1220
verified location signature clusters
First Order Location Models 1224
(includes distinct MS location models that output location hypotheses)
Location Center Control Subsystem 1350
SUPERVISOR
1. Controls location estimation system;
2. Determines context or state of location problem;eg. first or second set of measmts for MS;
3. Determines appropriate replies to BSs;
4. Notes "health" of BS measmts;
OPERATOR INTERFACE
1374
LOCATION ENGINE 139
Neural Net Training Data Base
Location Signature Data Base
1320
1. Stores CDMA signal characteristics for verified locations (e.g. location signatures or loc sigs);
2. Each Loc Sig allows access to MS lat-long, BS ID, power levels (BS and MS), time/date stamp, environmental measurmts indicating: e.g., RF bkgnd noise, multipath, dense urban, urban, suburban, rural, mountain, weather, traffic, and a confidence value for the loc sig.
3. Supported retrievals: by geographical area, by BS ID, by environmental measurmt classifications, by time/date range.
4. Loc Sigs input from 2 sources: fixed location MSs (e.g., LBS's, 12 loc sigs/LBS/day for 3 yr), other verified sources provided by a MBS or another unit having location verification functionality, e.g., police, ambulances, buses, taxi
ENVIRONMENTAL DATA BASE 1354
1. Stores current weather, traffic etc conditions.
2. Used by Context Adjuster, Anal Reasoner & may be FOMs
Pathway Data Base
Area Characteristics Data Base 1450
Hypothesis Evaluator 1228
Context Adjuster 1326
1. Adjusts the confidence and/or area fields of location hypotheses output by First Order Models to obtain more reliable target MS estimates using verified location signature clusters in the Location Signature DB.
2. In one embodiment, this module modifies a target MS location in relation to various environmental characteristics such as: the geographical area (type) associated with a location hypothesis, weather, time of day, season, traffic, etc;
3. In one embodiment, may use heuristic (fuzzy logic) rules to adjust the confidence values;
4. In one embodiment, may also use expert system rules for adjusting confidences due to BS failure(s).
5. For LBSs (fixed location transceivers), may use output from the First Order Models for such transceivers as a way to calibrate location hypothesis default confidence values of other FOMs.
Location Hypothesis Analyzer 1332
(includes Blackboard and/or Expert System)
MS Status Repository (run-time tracking)
1. Run-time storage for previous target MS path or tracking data; e.g., previous target MS location hypotheses & location predictions for recently located MSs; e.g., MS paths may be stored here for use in extrapolating a new MS location estimate.
2. Log context or state of a target MS location problem;eg. first or second set of measmts for target MS.
Performance Data Base
1. Data here is used with the ADAPTATION ENGINE (e.g., for tuning the CONTEXT ADJUSTER)
Adaptation Engine
1. Background process to adaptively tune the location engine 139;
2. Uses stored data to adjust sys parameters according to past performances;
3. General purpose, uses no domain knowledge
1382
Location Estimator
1. Receives resulting location hypotheses (with highest confidences) and attempts to output a single (set of nested) area(s) with probabilities associated with each area
1344
1338
1356
Output Gateway (to Designated Location Applications)
1. Determines the applications receiving output and the frequency of output to each application
Public Telephone Switching Network 129, Internet 468, MSC 112, SMS 105, and SCP 104

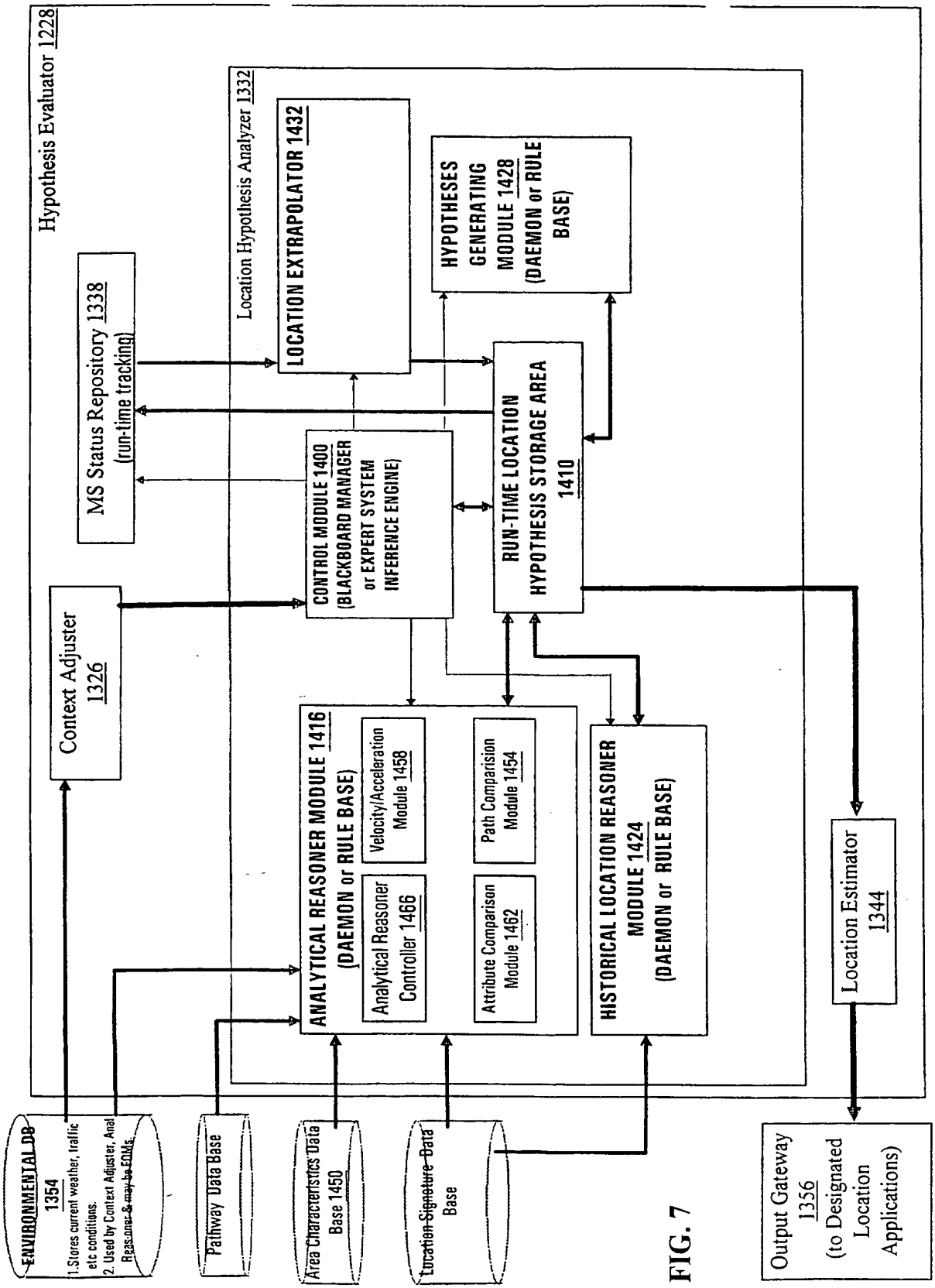
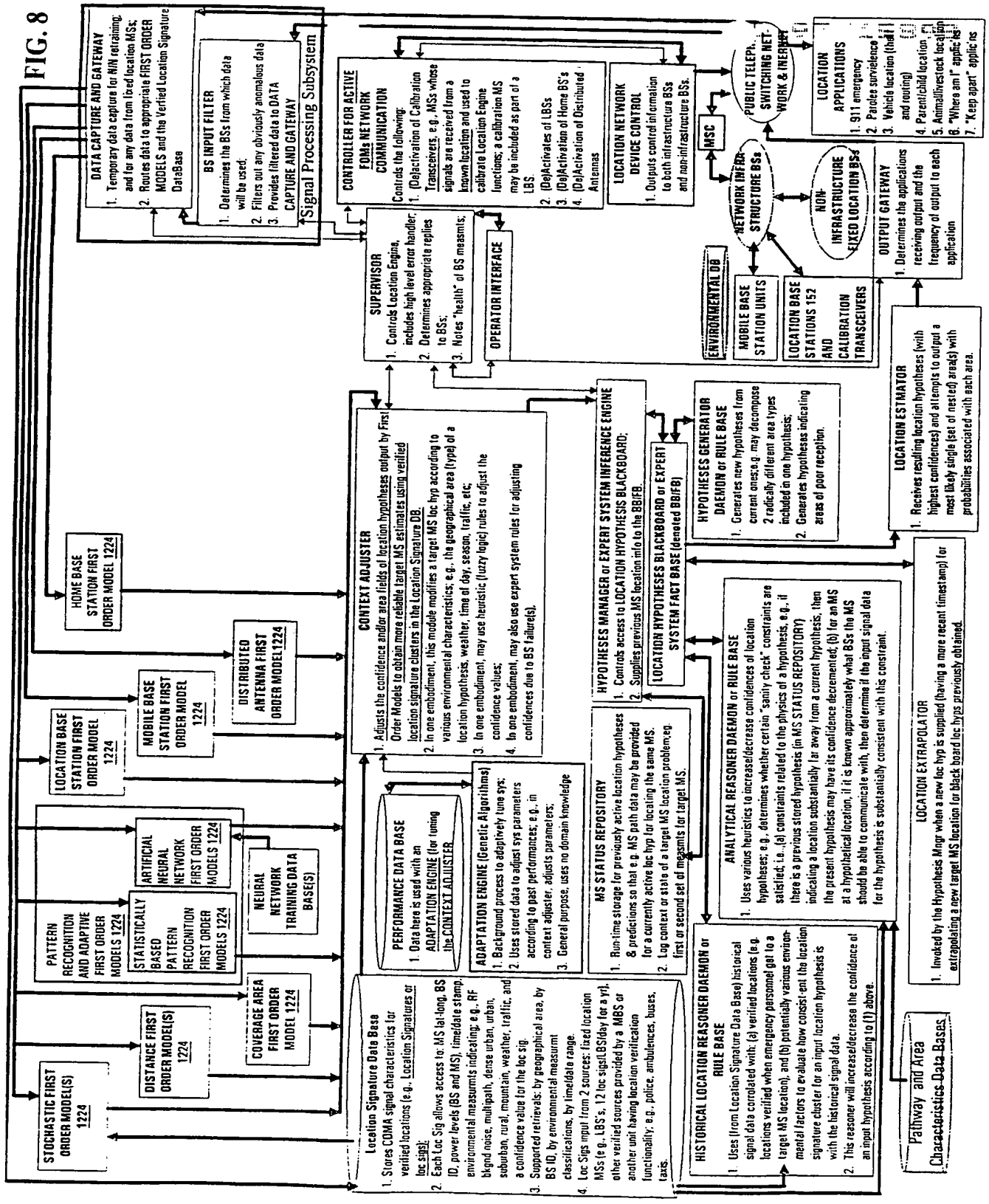


FIG. 7

Control flows are thin arrows, major data flows are thick arrows.

FIG. 8


DATA CAPTURE AND GATEWAY
1. Temporary data capture for N/N retraining; and for any data from fixed location MSs;
2. Routes data to appropriate FIRST ORDER MODELS and the Verified Location Signature DataBase
BS INPUT FILTER
1. Determines the BSs from which data will be used;
2. Filters out any obviously anomalous data
3. Provides filtered data to DATA CAPTURE AND GATEWAY
Signal Processing Subsystem
CONTROLLER FOR ACTIVE FOMs NETWORK COMMUNICATION
Controls the following:
1. (De)activation of Calibration Transceivers, e.g. MSs whose signals are received from a known location and used to calibrate Location Engine functions; a calibration MS may be included as part of a LBS;
2. (De)Activates of LBSs
3. (De)Activation of Home BS's
4. (De)Activation of Distributed Antennas
LOCATION NETWORK DEVICE CONTROL
1. Outputs control information to both infrastructure BSs and non-infrastructure BSs.
PUBLIC TELEPH. SWITCHING NETWORK & INTERNET
MSC
NETWORK INFRASTRUCTURE BSs
NON-INFRASTRUCTURE FIXED LOCATION BSs
LOCATION APPLICATIONS
1. 911 emergency
2. Parolee surveillance
3. Vehicle location (theft and routing)
4. Parent/child location
5. Animal/livestock location
6. "Where am I" applications
7. "Keep apart" applications
OUTPUT GATEWAY
1. Determines the applications receiving output and the frequency of output to each application
LOCATION ESTIMATOR
1. Receives resulting location hypotheses (with highest confidences) and attempts to output a most likely single (set of nested) area(s) with probabilities associated with each area.
HYPOTHESES GENERATOR DAEMON or RULE BASE
1. Generates new hypotheses from current ones;e.g. may decompose 2 radically different area types included in one hypothesis;
2. Generates hypotheses indicating areas of poor reception.
SUPERVISOR
1. Controls Location Engine, includes high level error handler;
2. Determines appropriate replies to BSs;
3. Notes "health" of BS measmts;
OPERATOR INTERFACE
ENVIRONMENTAL DB
MOBILE BASE STATION UNITS
LOCATION BASE STATIONS 152 AND CALIBRATION TRANSCEIVERS
CONTEXT ADJUSTER
1. Adjusts the confidence and/or area fields of location hypotheses output by First Order Models to obtain more reliable target MS estimates using verified location signature clusters in the Location Signature DB.
2. In one embodiment, this module modifies a target MS loc hyp according to various environmental characteristics; e.g., the geographical area (type) of a location hypothesis, weather, time of day, season, traffic, etc;
3. In one embodiment, may use heuristic (fuzzy logic) rules to adjust the confidence values;
4. In one embodiment, may also use expert system rules for adjusting confidences due to BS failure(s).
HYPOTHESES MANAGER or EXPERT SYSTEM INFERENCE ENGINE
1. Controls access to LOCATION HYPOTHESIS BLACKBOARD;
2. Supplies previous MS location info to the BB/FB.
LOCATION HYPOTHESES BLACKBOARD or EXPERT SYSTEM FACT BASE (denoted BB/FB)
HOME BASE STATION FIRST ORDER MODEL 1224
DISTRIBUTED ANTENNA FIRST ORDER MODEL1224
LOCATION BASE STATION FIRST ORDER MODEL 1224
MOBILE BASE STATION FIRST ORDER MODEL 1224
ARTIFICIAL NEURAL NETWORK FIRST ORDER MODELS 1224
STATISTICALLY BASED PATTERN RECOGNITION FIRST ORDER MODELS 1224
PATTERN RECOGNITION AND ADAPTIVE FIRST ORDER MODELS 1224
NEURAL NETWORK TRAINING DATA BASE(S)
COVERAGE AREA FIRST ORDER MODEL 1224
DISTANCE FIRST ORDER MODEL(S) 1224
STOCHASTIC FIRST ORDER MODEL(S) 1224
PERFORMANCE DATA BASE
1. Data here is used with an ADAPTATION ENGINE (for tuning the CONTEXT ADJUSTER
ADAPTATION ENGINE (Genetic Algorithms)
1. Background process to adaptively tune sys;
2. Uses stored data to adjust sys parameters according to past performances; e.g., in context adjuster, adjusts parameters;
3. General purpose, uses no domain knowledge
MS STATUS REPOSITORY
1. Run-time storage for previously active location hypotheses & predictions so that e.g. MS path data may be provided for a currently active loc hyp for locating the same MS.
2. Log context or state of a target MS location problem;eg. first or second set of measmts for target MS.
ANALYTICAL REASONER DAEMON or RULE BASE
1. Uses various heuristics to increase/decrease confidences of location hypotheses; e.g., determines whether certain "sanity check" constraints are satisfied; i.e., (a) constraints related to the physics of a hypothesis, e.g., if there is a previous stored hypothesis (in MS STATUS REPOSITORY) indicating a location substantially far away from a current hypothesis, then the present hypothesis may have its confidence decremented; (b) for an MS at a hypothetical location, if it is known approximately what BSs the MS should be able to communicate with, then determine if the input signal data for the hypothesis is substantially consistent with this constraint.
HISTORICAL LOCATION REASONER DAEMON or RULE BASE
1. Uses (from Location Signature Data Base) historical signal data correlated with: (a) verified locations (e.g. locations verified when emergency personnel got to a target MS location), and (b) potentially various environmental factors to evaluate how consistent the location signature cluster for an input location hypothesis is with the historical signal data.
2. This reasoner will increase/decrease the confidence of an input hypothesis according to (1) above.
LOCATION EXTRAPOLATOR
1. Invoked by the Hypothesis Mngr when a new loc hyp is supplied (having a more recent timestamp) for extrapolating a new target MS location for black board loc hyps previously obtained.
Location Signature Data Base
1. Stores CDMA signal characteristics for verified locations (e.g., Location Signatures or loc sigs);
2. Each Loc Sig allows access to: MS lat-long, BS ID, power levels (BS and MS), time/date stamp, environmental measurmts indicating: e.g. RF bkgnd noise, multipath, dense urban, urban, suburban, rural, mountain, weather, traffic, and a confidence value for the loc sig.
3. Supported retrievals: by geographical area, by BS ID, by environmental measurmt classifications, by time/date range.
4. Loc Sigs input from 2 sources: fixed location MSs (e.g., LBS's, 12 loc sigs/LBS/day for a yr), other verified sources provided by a MBS or another unit having location verification functionality; e.g., police, ambulances, buses, taxis.
Pathway and Area Characteristics Data Bases

DATA STRUCTURE FOR A LOCATION HYPOTHESIS

FOM_ID: First Order Model ID (providing this Location Hypothesis); note, since it is possible for location hypotheses to be generated by other than the FOM's, in general this field identifies the module that generated this location hypothesis.

MS_ID: The identification of the target MS to which this location hypothesis applies.

pt_est: The most likely location point estimate of the target MS

valid_pt: Boolean indicating the validity of "pt_est"

area_est: Location Area Estimate of the target MS provided by the FOM. This area estimate will be used whenever "image_area" below is NULL.

valid_area: Boolean indicating the validity of "area_est" (one of "pt_est" and "area_est" must be valid).

adjust: Boolean (true iff adjustments to the fields of this location hypothesis are to be performed in the Context Adjuster Module)

pt_covering: reference to a substantially minimal area (e.g., mesh cell) covering of "pt_est". Note, since this MS may be substantially on a cell boundary, this covering may in some cases include more than one cell.

image_area: reference to an area (e.g., mesh cell) covering of the image cluster set area for "pt_covering" (see detailed description of the function, "confidence_adjuster"). Note that if this field is not NULL, then this is the target MS location estimate used by the Location Center instead of "area_est".

extrapolation_area: reference to (if non-NULL) an extrapolated MS target estimate area provided by the Location Extrapolator submodule of the Hypothesis Analyzer. That is, this field, if non_NULL, is an extrapolation of the "image_area" field if it exists, otherwise this field is an extrapolation of the "area_est" field. Note other extrapolation fields may also be provided depending on the embodiment of the present invention, such as an extrapolation of the "pt_covering".

confidence: A real value in the range [-1.0, +1.0] indicating a likelihood that the target MS is in (or out) of a particular area. If positive: if "image_area" exists, then this is a measure of the likelihood that the target MS is within the area represented by "image_area," else if "image_area" has not been computed (e.g., "adjust" is FALSE), then "area_est" must be valid and this is a measure of the likelihood that the target MS is within the area represented by "area_est." If negative, then "area_est" must be valid and this is a measure of the likelihood that the target MS is NOT in the area represented by "area_est". If it is zero (near zero), then the likelihood is unknown.

Original_Timestamp: Date and time that the location signature cluster for this location hypothesis was received by the CDMA Filter Subsystem,

Active_Timestamp: Run-time field providing the time to which this location hypothesis has had its MS location estimate(s) extrapolated (in the Location Extrapolator of the Hypothesis Analyzer). Note that this field is initialized with the value from the "Original_Timestamp" field.

Processing Tags and environmental categorizations: For indicating particular types of environmental classifications not readily determined by the Original_Timestamp field (e.g., weather, traffic), and restrictions on location hypothesis processing.

loc_sig_cluster: Access to location signature signal characteristics provided to the First Order Models by the CDMA Filter Subsystem; i.e., access to the "loc sigs" (received at "timestamp" regarding the location of the target MS)

descriptor: Optional descriptor (from the First Order Model indicating why/how the Location Area Estimate and Confidence Value were determined)

FIG. 9

FIG. 10

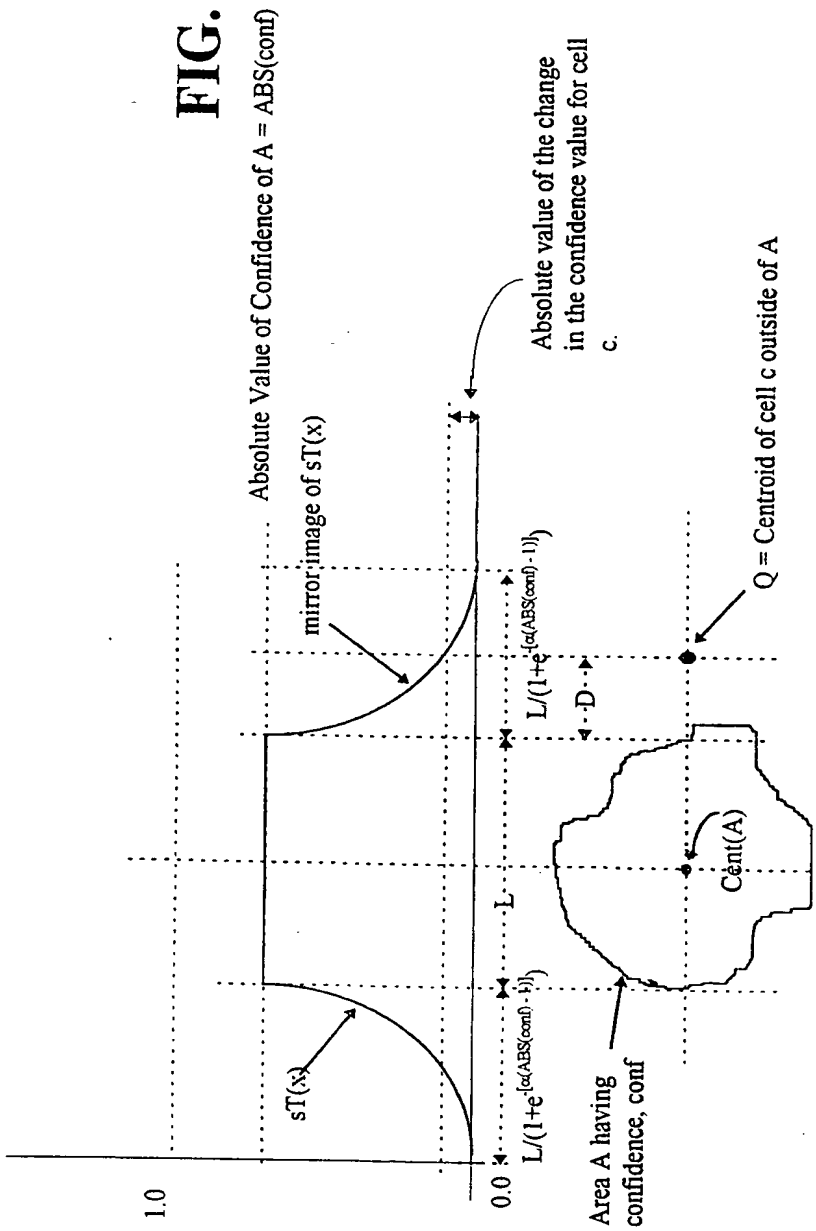
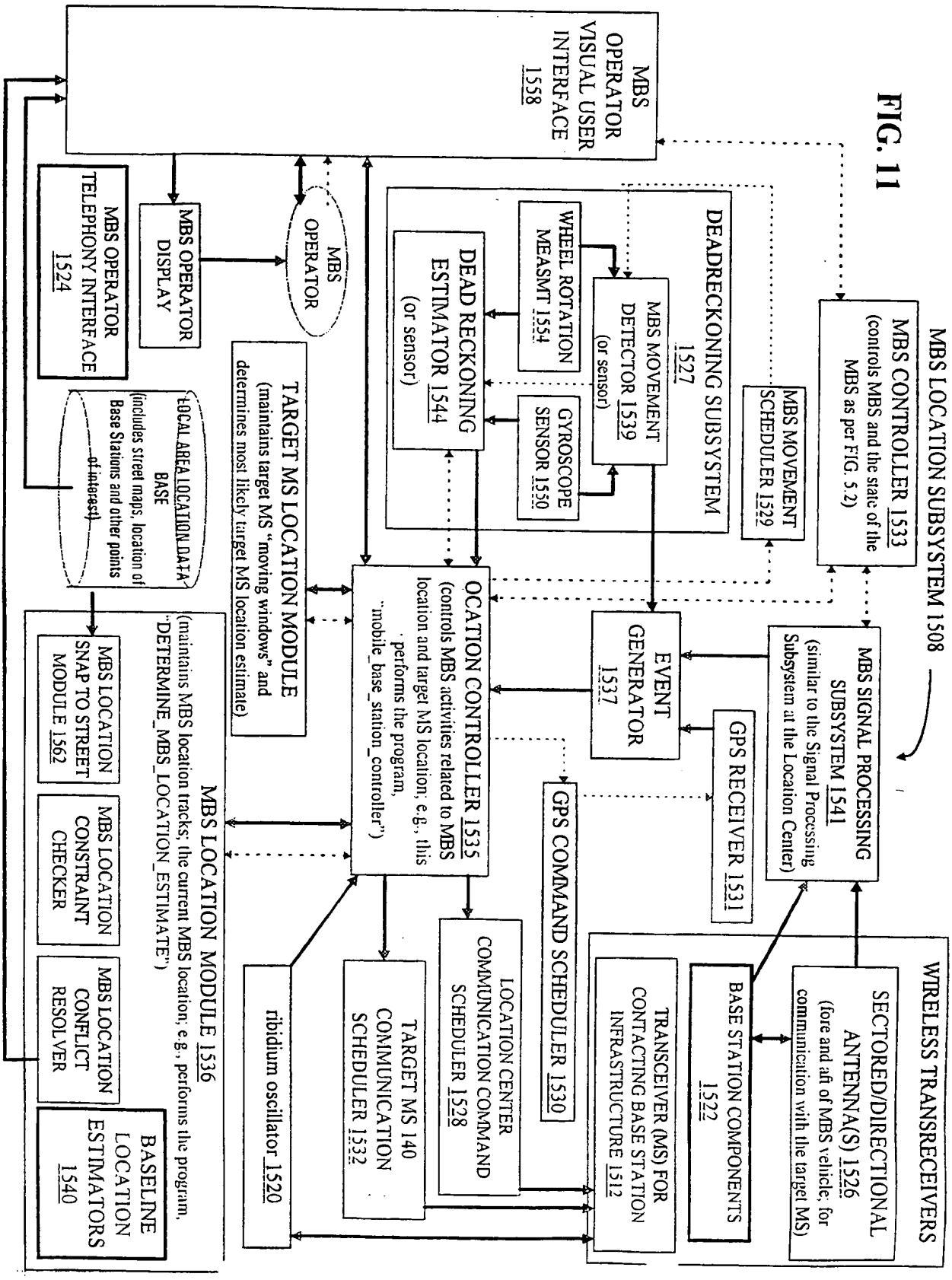

Absolute Value of Confidence of A = ABS(conf)
Absolute value of the change in the confidence value for cell c.
mirror image of sT(x)
Q = Centroid of cell c outside of A
L/(1+e^{(α(ABS(conf) - 1))})
D
Cent(A)
L
sT(x)
L/(1+e^{(α(ABS(conf) - b))})
1.0
0.0
Area A having confidence, conf

FIG. 11


MBS LOCATION SUBSYSTEM 1508
MBS CONTROLLER 1533
(controls MBS and the state of the MBS as per FIG. 5.2)
MBS MOVEMENT SCHEDULER 1529
MBS SIGNAL PROCESSING SUBSYSTEM 1541
(similar to the Signal Processing Subsystem at the Location Center)
WIRELESS TRANSRECEIVERS
SECTORED/DIRECTIONAL ANTENNA(S) 1526
(fore and aft of MBS vehicle, for communication with the target MS)
BASE STATION COMPONENTS 1522
TRANSCEIVER (MS) FOR CONTACTING BASE STATION INFRASTRUCTURE 1512
MBS OPERATOR VISUAL USER INTERFACE 1558
DEADRECKONING SUBSYSTEM 1527
WHEEL ROTATION MEASMT 1554
MBS MOVEMENT DETECTOR 1539
(or sensor)
GYROSCOPE SENSOR 1550
DEAD RECKONING ESTIMATOR 1544
(or sensor)
EVENT GENERATOR 1537
GPS RECEIVER 1531
GPS COMMAND SCHEDULER 1530
OCATION CONTROLLER 1535
(controls MBS activities related to MBS location and target MS location; e.g., this performs the program, "mobile_base_station_controller")
LOCATION CENTER COMMUNICATION COMMAND SCHEDULER 1528
TARGET MS 140 COMMUNICATION SCHEDULER 1532
ribidium oscillator 1520
MBS OPERATOR
MBS OPERATOR DISPLAY
MBS OPERATOR TELEPHONY INTERFACE 1524
TARGET MS LOCATION MODULE
(maintains target MS "moving windows" and determines most likely target MS location estimate)
LOCAL AREA LOCATION DATA BASE
(includes street maps, location of Base Stations and other points of interest)
MBS LOCATION MODULE 1536
(maintains MBS location tracks; the current MBS location; e.g., performs the program, "DETERMINE_MBS_LOCATION_ESTIMATE")
MBS LOCATION SNAP TO STREET MODULE 1562
MBS LOCATION CONSTRAINT CHECKER
MBS LOCATION CONFLICT RESOLVER
BASELINE LOCATION ESTIMATORS 1540

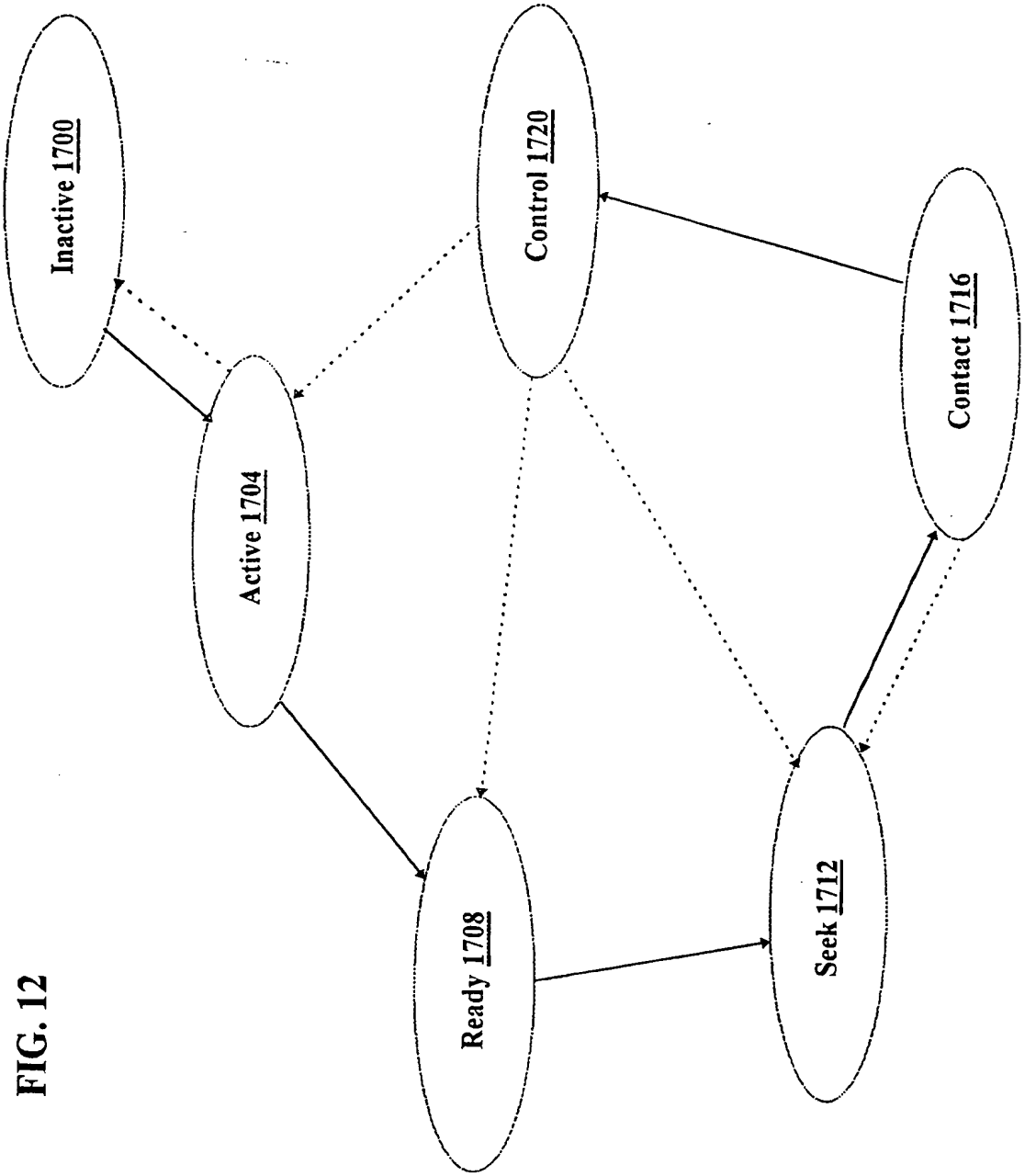

Inactive 1700
Control 1720
Contact 1716
Active 1704
Ready 1708
Seek 1712

FIG. 12

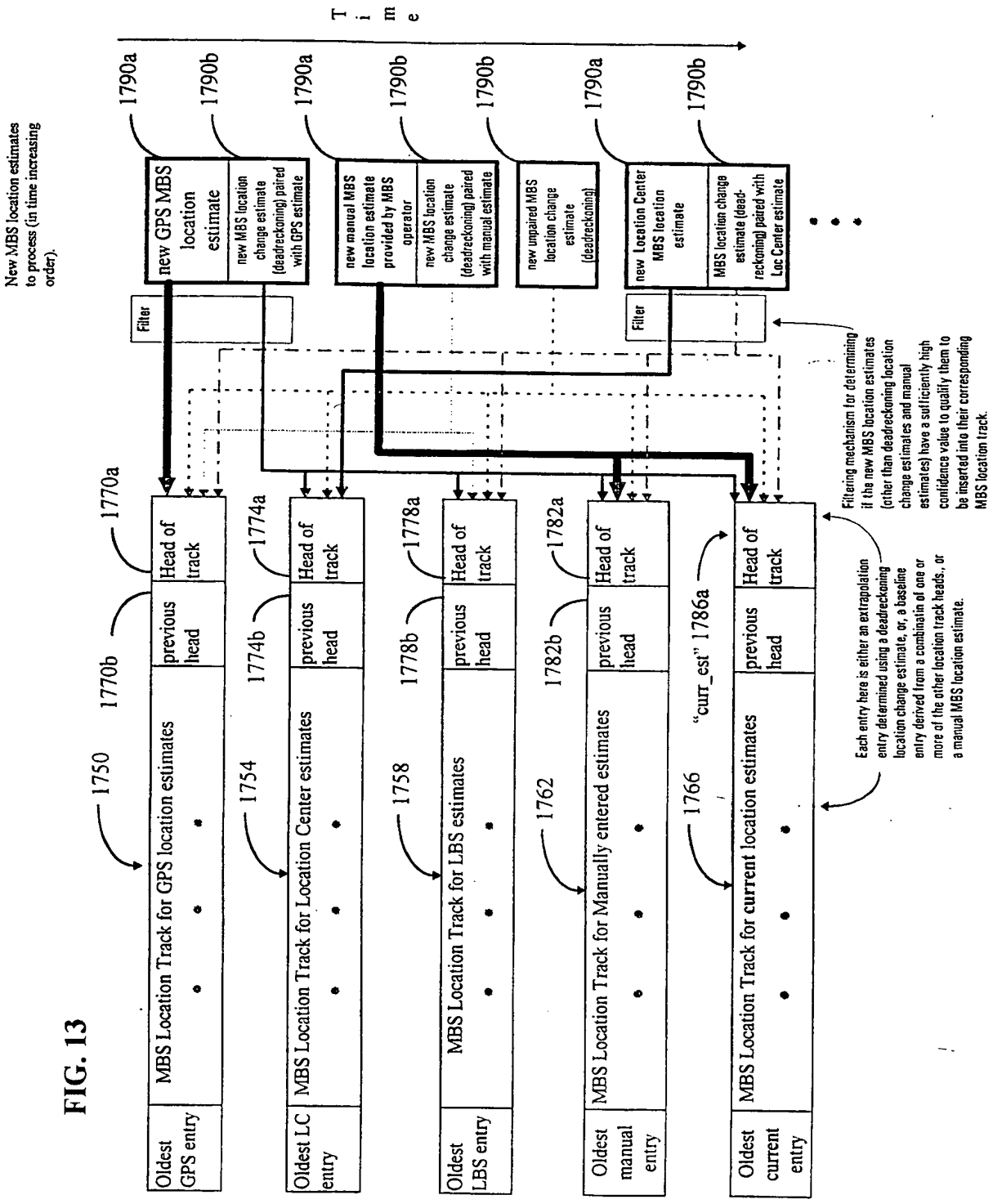

Time
New MBS location estimates to process (in time increasing order).
1790a
1790b
new GPS MBS location estimate
new MBS location change estimate (deadreckoning) paired with GPS estimate
new manual MBS location estimate provided by MBS operator
new MBS location change estimate (deadreckoning) paired with manual estimate
new unpaired MBS location change estimate (deadreckoning)
new Location Center MBS location estimate
MBS location change estimate (dead-reckoning) paired with Loc Center estimate
Filter
Filter
1770a
1770b
1774a
1774b
1778a
1778b
1782a
1782b
"curr_est" 1786a
Head of track
previous head
1750
1754
1758
1762
1766
MBS Location Track for GPS location estimates
MBS Location Track for Location Center estimates
MBS Location Track for LBS estimates
MBS Location Track for Manually entered estimates
MBS Location Track for current location estimates
Oldest GPS entry
Oldest LC entry
Oldest LBS entry
Oldest manual entry
Oldest current entry
Filtering mechanism for determining if the new MBS location estimates (other than deadreckoning location change estimates and manual estimates) have a sufficiently high confidence value to qualify them to be inserted into their corresponding MBS location track.
Each entry here is either an extrapolation entry determined using a deadreckoning location change estimate, or, a baseline entry derived from a combination of one or more of the other location track heads., or a manual MBS location estimate.

FIG. 13

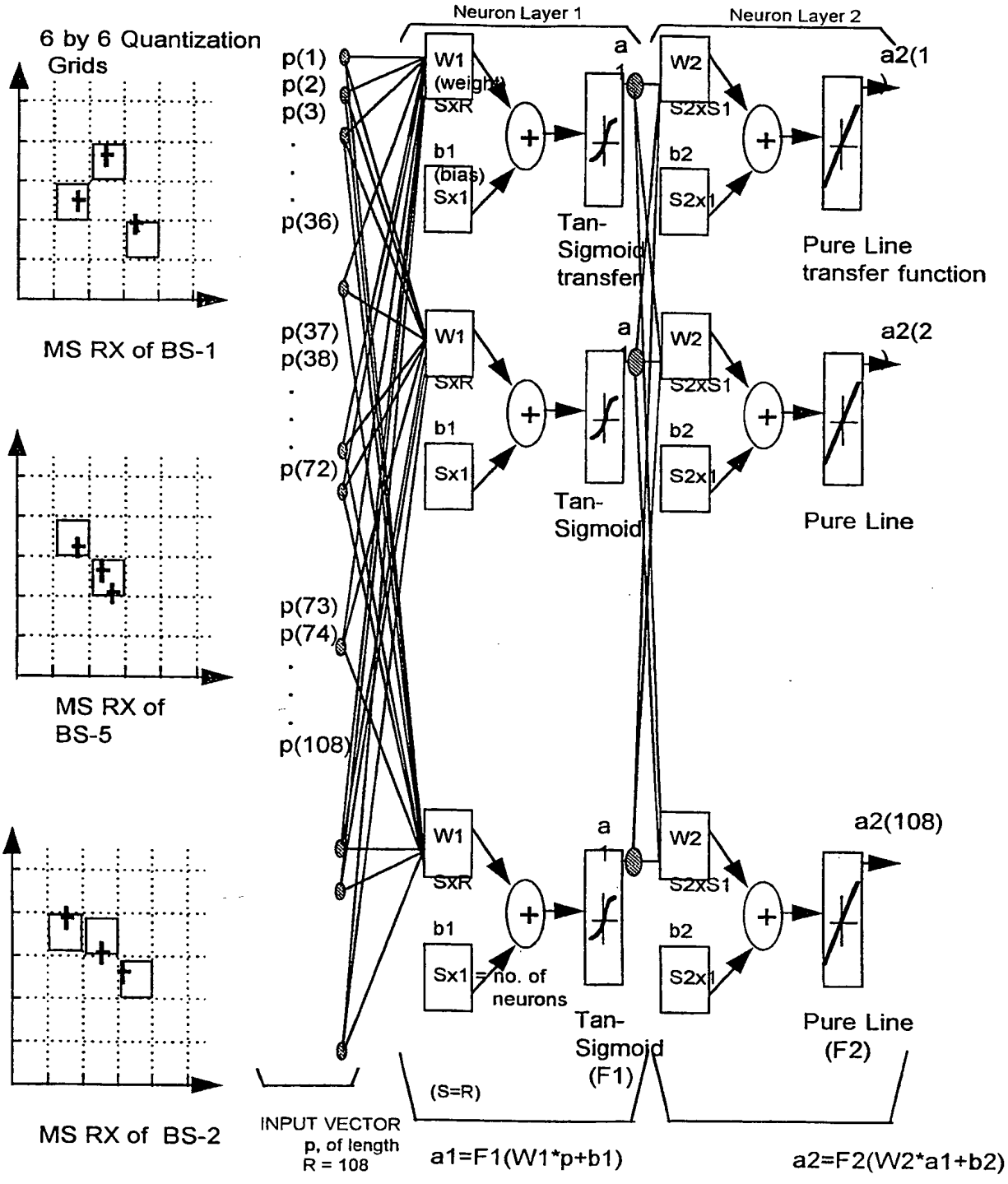


Figure 14: Neural Network Architecture: 2 of 3 Layers shown (Dense Urban Canyon)

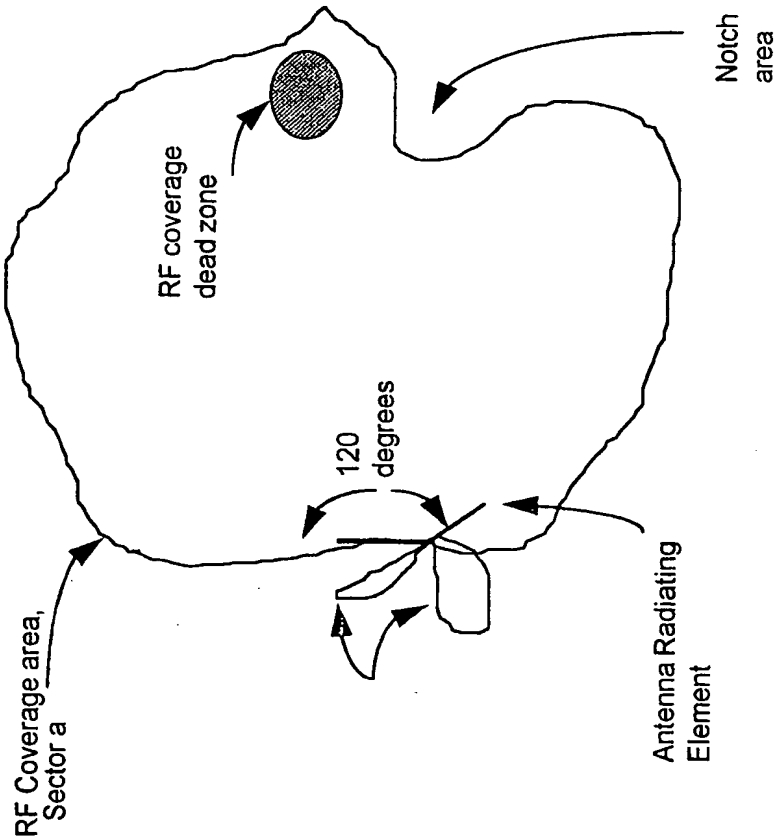


Figure 15: Typical Single-Sector Radiator Pattern, with Dead Zone and Notch

Fig. 16a

Location Signature Data Type

MS_type: The make and model of the target MS 140 associated with a location signature instantiation;

BS_id: An identification of the base station 122 (location base station 152) communicating with the target MS;

verified_flag: TRUE iff a location of MS_loc has been verified, FALSE otherwise. Note, if this field is TRUE (i.e., the loc sig is verified), then the base station identified by BS_id is the current primary base station for the target MS;

MS_loc: If verified_flag is TRUE, then this attribute includes an estimated location of the target MS.

If verified_flag is FALSE, then this attribute has a value indicating "location unknown".

Note this attribute may include the following two subfields: an area within which the target MS is presumed to be, and a point location (e.g., a latitude and longitude pair) where the target MS is presumed to be (in one embodiment this is the centroid of the area);

confidence: a value indicating how consistent this loc sig is with other loc sigs in the location signature data base 1320; the value for this entry is in the range [0, 1] with 0 corresponding to the lowest (i.e., no) confidence and 1 corresponding to the highest confidence;

timestamp: The time and date when the location signature was received by the base station of BS_id;

Fig. 16b

signal topography characteristics:

Characteristics of at a generated surface(s), the surface(s) being generated by the signal filtering subsystem 1220 using signal measurements between the MS and BS associated with the loc sig, wherein the measurements were accumulated over a particular (relatively short) time interval. For example, the dimensions for the generated surface may be signal strength and time delay. By sampling such signal characteristics and tallying the samples in each of a plurality of mesh cells, a mountainous surface can be obtained. Such a surface, is believed, under most circumstances, to provide a contour that is substantially unique to the location of the target MS 140. The attributes of such a surface(s) retained in the signal topography characteristics here include, for example: for each local maximum (of the surface) above a predetermined noise ceiling threshold, the (signal strength, time delay) coordinates of the cell of the local maximum and the corresponding height of the local maximum. Additionally, certain gradients may also be included for characterizing the "steepness" of the surface mountains. Moreover, in some embodiments, a frequency may also be associated with each local maximum. Thus, the data retained for each selected local maximum can include a quadruple of signal strength, time delay, height and frequency;

quality_obj: This object includes one or more signal quality (or error) measurements (e.g., Eb/No values);

noise_ceiling: Noise ceiling values used in the initial filtering of noise (by the signal filtering subsystem 1220) from the surface(s) used in generating the signal topography characteristics;

Fig. 16c

power_level: The power levels of the associated BS 122 and MS 140 for the signal data used for this loc sig;

timing_error: An estimated (or maximum) timing error between the associated base station (e.g., an infrastructure base station 122 or a location base station 152) detecting the associated target MS 140 and the current primary BS 122 for this target MS. Note that if the BS 122 associated with the loc sig is the primary base station (e.g., when the loc sig is verified), then the value here will be zero;

cluster_ptr: A pointer to the location signature cluster to which this loc sig belongs.

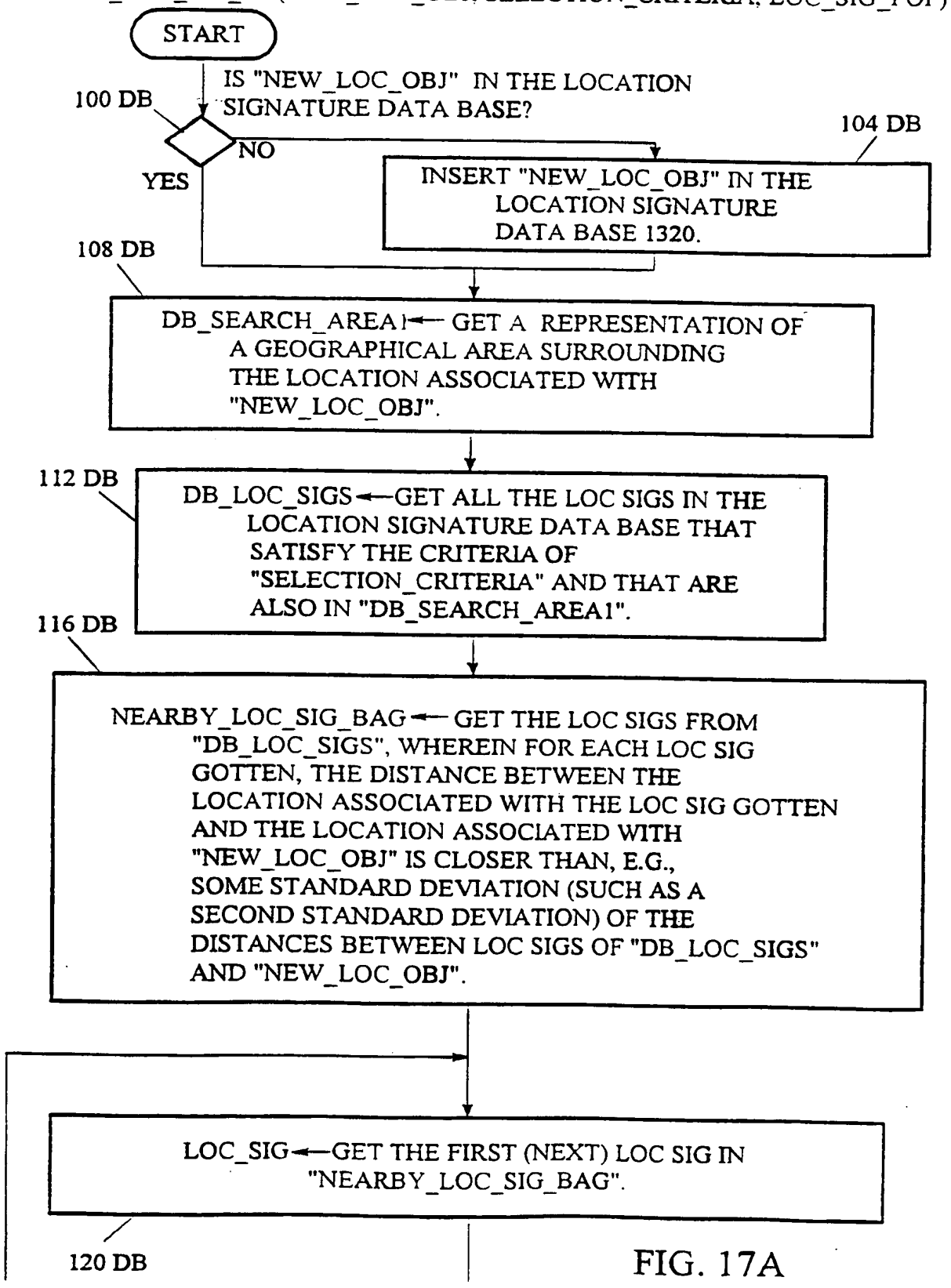

UPDATE_LOC_SIG_DB(NEW_LOC_OBJ, SELECTION_CRITERIA, LOC_SIG_POP)
START
100 DB
IS "NEW_LOC_OBJ" IN THE LOCATION SIGNATURE DATA BASE?
NO
YES
104 DB
INSERT "NEW_LOC_OBJ" IN THE LOCATION SIGNATURE DATA BASE 1320.
108 DB
DB_SEARCH_AREA1 ← GET A REPRESENTATION OF A GEOGRAPHICAL AREA SURROUNDING THE LOCATION ASSOCIATED WITH "NEW_LOC_OBJ".
112 DB
DB_LOC_SIGS ← GET ALL THE LOC SIGS IN THE LOCATION SIGNATURE DATA BASE THAT SATISFY THE CRITERIA OF "SELECTION_CRITERIA" AND THAT ARE ALSO IN "DB_SEARCH_AREA1".
116 DB
NEARBY_LOC_SIG_BAG ← GET THE LOC SIGS FROM "DB_LOC_SIGS", WHEREIN FOR EACH LOC SIG GOTTEN, THE DISTANCE BETWEEN THE LOCATION ASSOCIATED WITH THE LOC SIG GOTTEN AND THE LOCATION ASSOCIATED WITH "NEW_LOC_OBJ" IS CLOSER THAN, E.G., SOME STANDARD DEVIATION (SUCH AS A SECOND STANDARD DEVIATION) OF THE DISTANCES BETWEEN LOC SIGS OF "DB_LOC_SIGS" AND "NEW_LOC_OBJ".
LOC_SIG ← GET THE FIRST (NEXT) LOC SIG IN "NEARBY_LOC_SIG_BAG".
120 DB

FIG. 17A

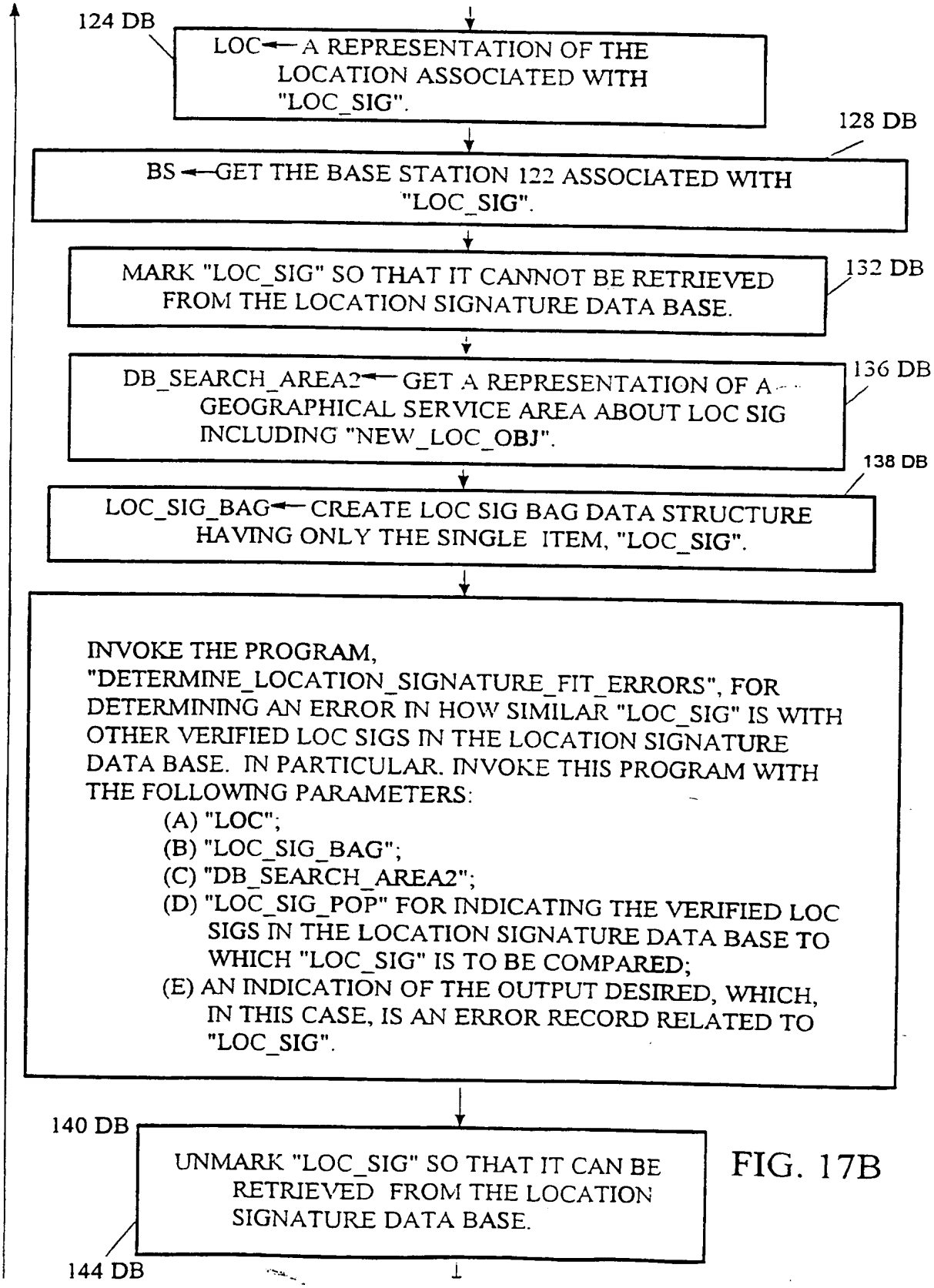

124 DB
LOC ← A REPRESENTATION OF THE LOCATION ASSOCIATED WITH "LOC_SIG".
128 DB
BS ← GET THE BASE STATION 122 ASSOCIATED WITH "LOC_SIG".
MARK "LOC_SIG" SO THAT IT CANNOT BE RETRIEVED FROM THE LOCATION SIGNATURE DATA BASE.
132 DB
DB_SEARCH_AREA2 ← GET A REPRESENTATION OF A GEOGRAPHICAL SERVICE AREA ABOUT LOC SIG INCLUDING "NEW_LOC_OBJ".
136 DB
LOC_SIG_BAG ← CREATE LOC SIG BAG DATA STRUCTURE HAVING ONLY THE SINGLE ITEM, "LOC_SIG".
138 DB
INVOKE THE PROGRAM, "DETERMINE_LOCATION_SIGNATURE_FIT_ERRORS", FOR DETERMINING AN ERROR IN HOW SIMILAR "LOC_SIG" IS WITH OTHER VERIFIED LOC SIGS IN THE LOCATION SIGNATURE DATA BASE. IN PARTICULAR, INVOKE THIS PROGRAM WITH THE FOLLOWING PARAMETERS:
(A) "LOC";
(B) "LOC_SIG_BAG";
(C) "DB_SEARCH_AREA2";
(D) "LOC_SIG_POP" FOR INDICATING THE VERIFIED LOC SIGS IN THE LOCATION SIGNATURE DATA BASE TO WHICH "LOC_SIG" IS TO BE COMPARED;
(E) AN INDICATION OF THE OUTPUT DESIRED, WHICH, IN THIS CASE, IS AN ERROR RECORD RELATED TO "LOC_SIG".
140 DB
UNMARK "LOC_SIG" SO THAT IT CAN BE RETRIEVED FROM THE LOCATION SIGNATURE DATA BASE.
144 DB

FIG. 17B

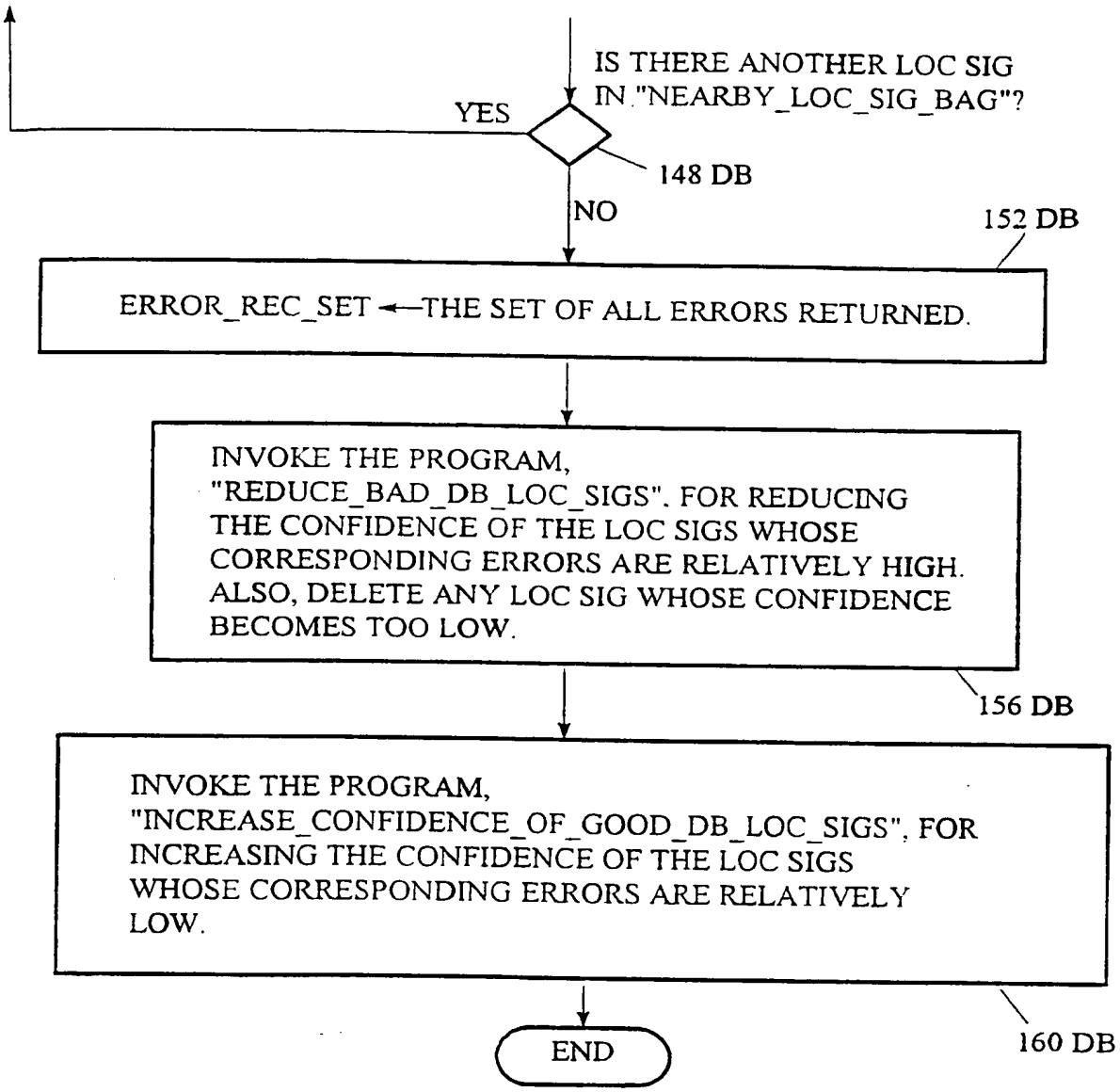

IS THERE ANOTHER LOC SIG IN "NEARBY_LOC_SIG_BAG"?
YES
148 DB
NO
152 DB
ERROR_REC_SET ←THE SET OF ALL ERRORS RETURNED.
INVOKE THE PROGRAM, "REDUCE_BAD_DB_LOC_SIGS", FOR REDUCING THE CONFIDENCE OF THE LOC SIGS WHOSE CORRESPONDING ERRORS ARE RELATIVELY HIGH. ALSO, DELETE ANY LOC SIG WHOSE CONFIDENCE BECOMES TOO LOW.
156 DB
INVOKE THE PROGRAM, "INCREASE_CONFIDENCE_OF_GOOD_DB_LOC_SIGS", FOR INCREASING THE CONFIDENCE OF THE LOC SIGS WHOSE CORRESPONDING ERRORS ARE RELATIVELY LOW.
160 DB
END

FIG. 17C

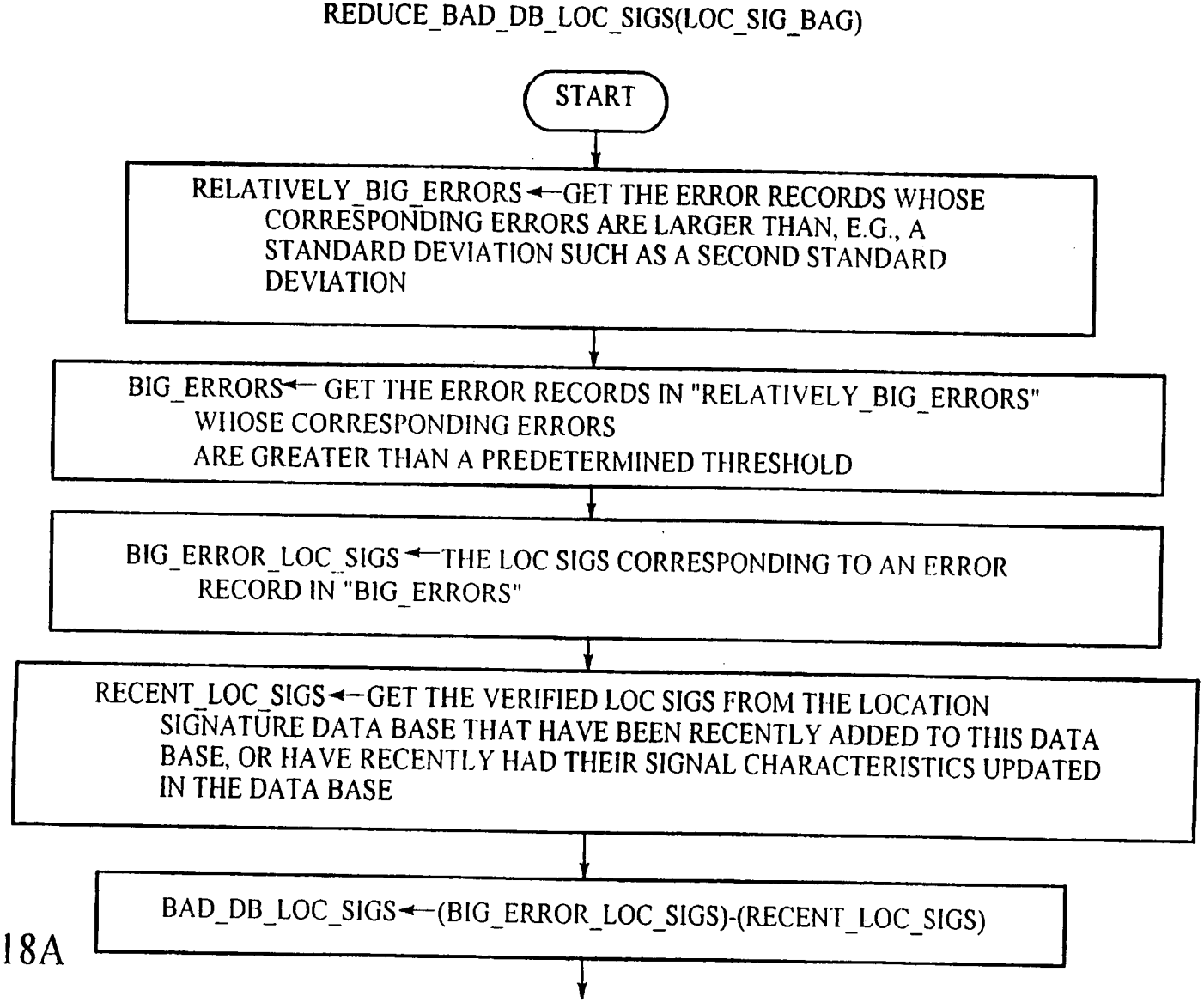


FIG. 18A

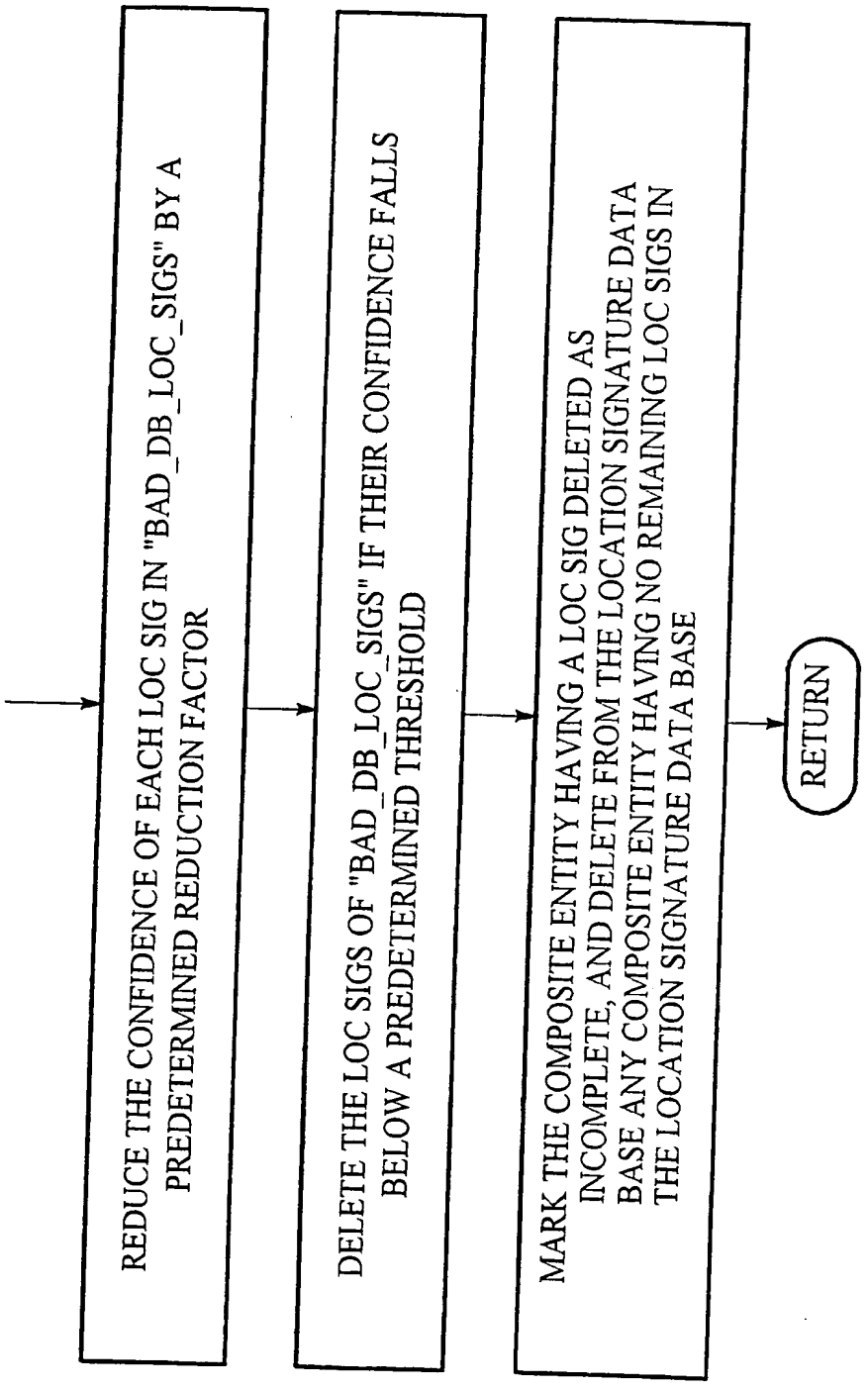

REDUCE THE CONFIDENCE OF EACH LOC SIG IN "BAD_DB_LOC_SIGS" BY A PREDETERMINED REDUCTION FACTOR
DELETE THE LOC SIGS OF "BAD_DB_LOC_SIGS" IF THEIR CONFIDENCE FALLS BELOW A PREDETERMINED THRESHOLD
MARK THE COMPOSITE ENTITY HAVING A LOC SIG DELETED AS INCOMPLETE, AND DELETE FROM THE LOCATION SIGNATURE DATA BASE ANY COMPOSITE ENTITY HAVING NO REMAINING LOC SIGS IN THE LOCATION SIGNATURE DATA BASE
RETURN

FIG. 18B

INCREASE_CONFIDENCE_OF_GOOD_DB_LOC_SIGS(LOC_SIG_BAG)

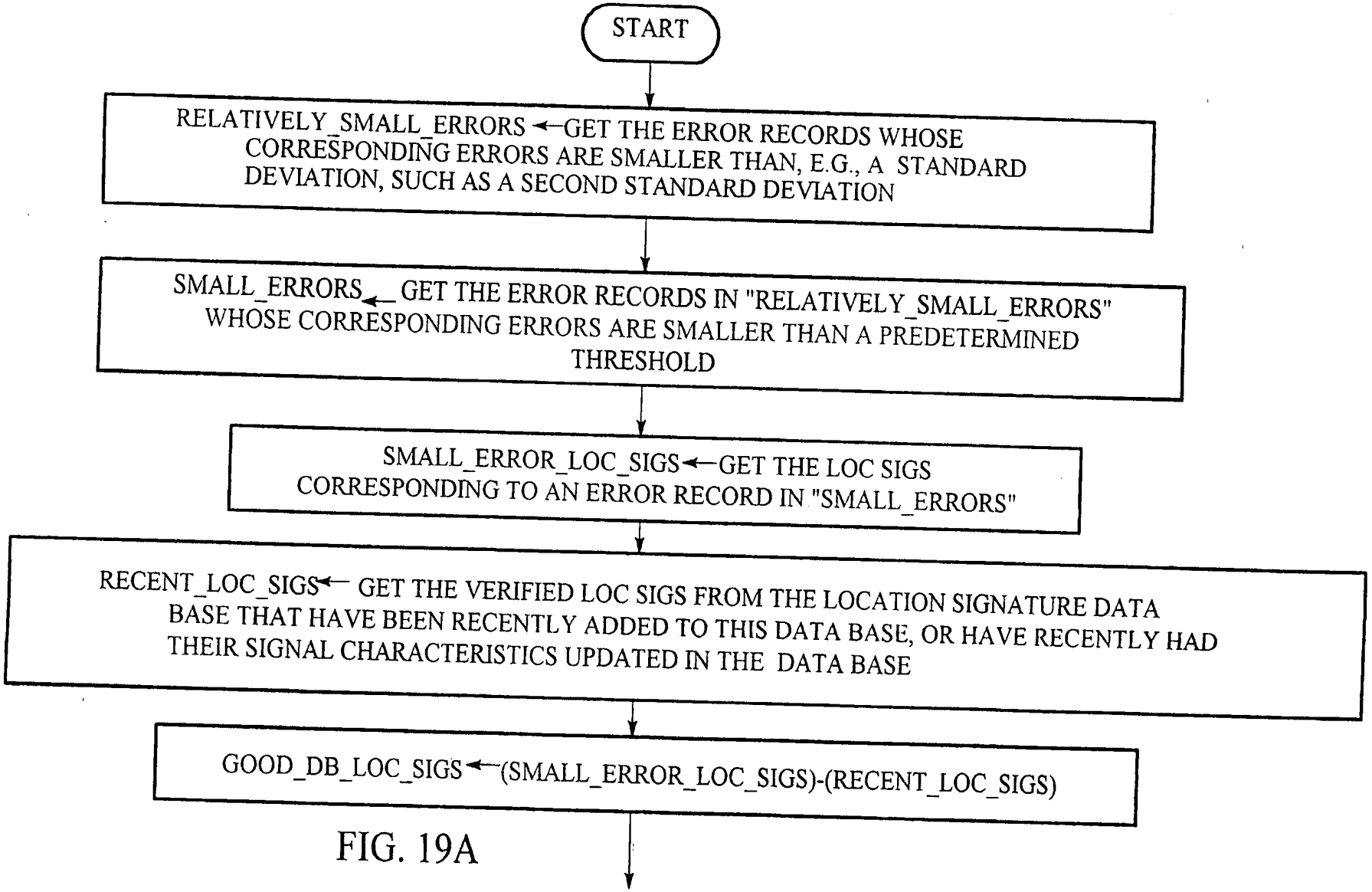


FIG. 19A

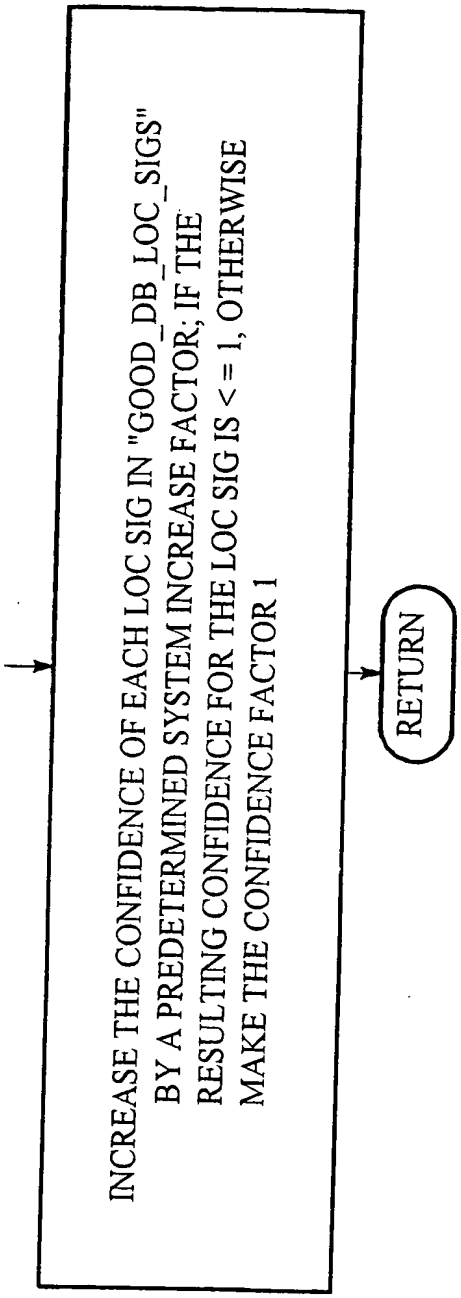

INCREASE THE CONFIDENCE OF EACH LOC SIG IN "GOOD_DB_LOC_SIGS"
BY A PREDETERMINED SYSTEM INCREASE FACTOR; IF THE
RESULTING CONFIDENCE FOR THE LOC SIG IS < = 1, OTHERWISE
MAKE THE CONFIDENCE FACTOR 1
RETURN

FIG. 19B

DETERMINE_LOCATION_SIGNATURE_FIT_ERRORS
(TARGET_LOC, TARGET_LOC_SIG_BAG, SEARCH_AREA_, SEARCH_CRITERIA,
OUTPUT_CRITERIA)
START
DB_BS_BAG←GET THE BASE STATION(S) 122 ASSOCIATED WITH THE VERIFIED LOC SIGS IN THE LOCATION SIGNATURE DATA BASE 1320 AT ALSO SATISFY THE CRITERIA OF "SEARCH_CRITERIA" AND HAVE THEIR VERIFIED LOCATIONS IN THE "SEARCH_AREA".
TARGET_BS_BAG←GET THE BASE STATION(S) 122 ASSOCIATED WITH THE LOC SIG(S) IN THE "TARGET_LOC_SIG_BAG".
TEST "OUTPUT_CRITERIA" TO DETERMINE THE BASE STATION(S) 122 FOR WHICH ERROR RECORDS ARE TO BE COMPUTED
OUTPUT_CRITERIA = "OUTPUT ERROR RECORDS FOR INPUT LOC SIGS ONLY"
BS_BAG←TARGET_BS_BAG
OUTPUT_CRITERIA = "OUTPUT ALL POSSIBLE ERROR RECORDS"
BS_BAG←(DB_BS_BAG)UNION(TARGET_BS_BAG)
BS_i←GET ANY FIRST (NEXT) BASE STATION 122 REPRESENTATION IN "BS_BAG"

FIG. 20A

FIG. 20B

DOES "BS$_i$" REPRESENT A BASE STATION 122 OR IS "BS$_i$" NIL?
NIL
REPRESENTS A BASE STATION
FOR EACH "BS$_i$" IN "BS_BAG" HAVING A VALID "ERROR_REC$_i$", INVOKE THE FUNCTION, "GET_DIFFERENCE_MEASUREMENT" WITH INPUTS: "TARGET_LOC_SIG$_i$", AND "COMPARISON_LOC_SIG$_i$" TO OBTAIN A DIFFERENCE OR ERROR MEASUREMENT FOR "EFFOR_REC$_i$" AND A CORRESPONDING CONFIDENCE VALUE FOR THE ERROR OBTAINED.
RETURN ALL ERROR RECORDS
COMPARISON_LOC_SIG_BAG←GET THE LOC SIGS FOR WHICH "BS$_i$" REPRESENTS THE ASSOCIATED BASE STATION 122 AND WHEREIN EACH OF THE LOC SIGS IS ASSOCIATED WITH A VERIFIED MS LOCATION IN "SEARCH_AREA" AND EACH OF THE LOC SIGS ALSO SATISFIES "SEARCH_CRITERIA".
(A) CREATE AN ERROR RECORD,FOR "ERROR_REC$_i$", FOR "BS$_i$", WHEREIN THE ERROR RECORD IS FOR RETAINING A MEASUREMENT (TO BE DETERMINED BELOW) OF THE DIFFERENCE BETWEEN:
(i) THE (ANY) LOC SIG WITH "BS$_i$" REPRESENTING THE ASSOCIATED BASE STATION 122, WHEREIN THIS LOC SIG EITHER IS IN "TARGET_LOC_SIG_BAG" OR IS A GENERATED LOC SIG ASSOCIATED WITH AN MS 140 AT "TARGET_LOC" THAT IS NOT DISTINGUISHABLE FROM THE NOISE; AND
(ii) THE (ANY) DERIVED LOC SIG OBTAINED FROM THE LOC SIG(S) OF "COMPARISON_LOC_SIG_BAG";
(B) SET A FLAG FOR THIS ERROR RECORD INDICATING THAT IT IS VALID.

IS THE DENSITY OF THE LOC SIGS IN "COMPARISON_LOC_SIG_BAG" WITHIN THE AREA OF "SEARCH_AREA" AT LEAST MINIMALLY SUFFICIENT TO CONTINUE?
NO
MARK THE ERROR RECORD, "ERROR_REC$_i$", FOR "BS$_i$" AS INVALID.
YES
IS "BS$_i$" IN "TARGET_BS_BAG"?
NO (SO "BS$_i$" ONLY IN "DB_BS_BAG")
YES
TARGET_LOC_SIG$_i$ ← GET THE LOC SIG IN "TARGET_BS_BAG" WHEREIN "BS$_i$" REPRESENTS THE ASSOCIATED BASE STATION 122
IS "TARGET_LOC_SIG_BAG" AN UNVERIFIED LOC SIG CLUSTER?
NO
YES
TARGET_LOC_SIG$_i$ ← GET A GENERATED LOC SIG WHOSE COORDINATES CORRESPOND TO A NOISE CEILING
WAS THE BASE STATION 122 FOR "BS$_i$" DETECTED AT ALL?
NO (SO "BS$_i$" SIGNALS ARE IN THE NOISE)
YES

FIG. 20C

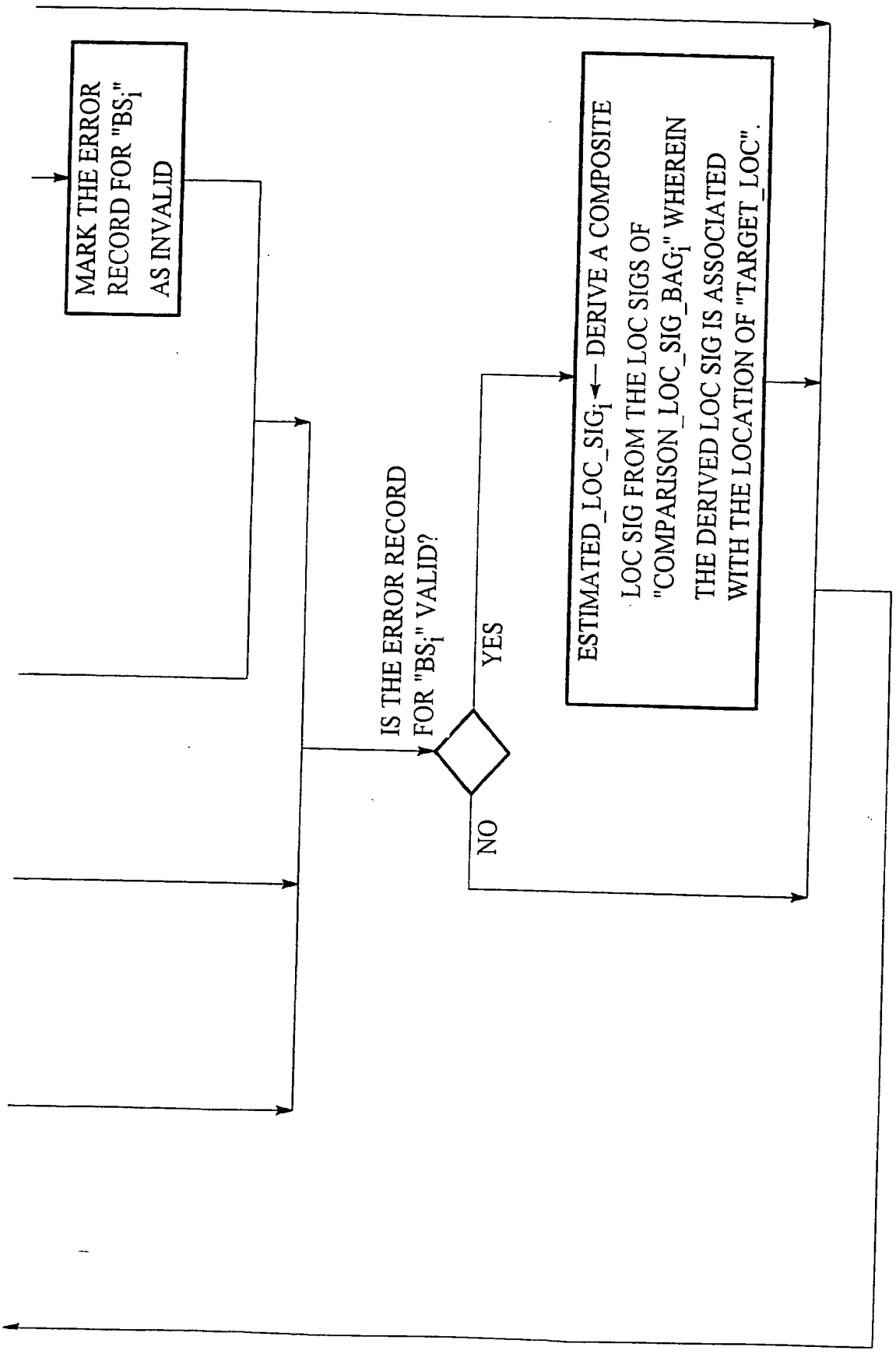

MARK THE ERROR RECORD FOR "BS$_i$" AS INVALID
IS THE ERROR RECORD FOR "BS$_i$" VALID?
YES
NO
ESTIMATED_LOC_SIG$_i$ ← DERIVE A COMPOSITE LOC SIG FROM THE LOC SIGS OF "COMPARISON_LOC_SIG_BAG$_i$" WHEREIN THE DERIVED LOC SIG IS ASSOCIATED WITH THE LOCATION OF "TARGET_LOC".

FIG. 20D

ESTIMATE_LOC_SIG_FROM_DB(LOC_FOR_ESTIMATION, BS, BS_SIG_BAG)

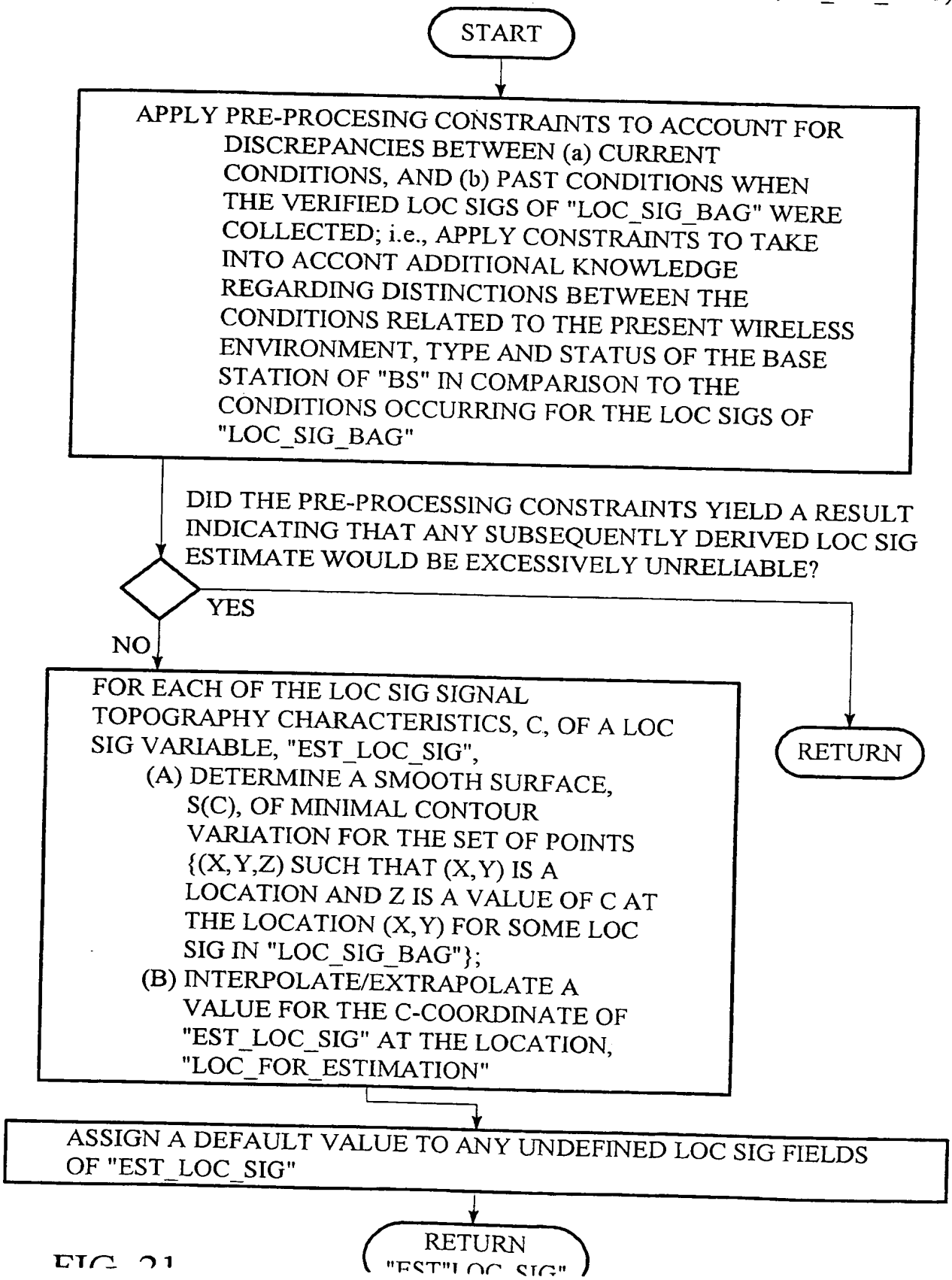


FIG. 21

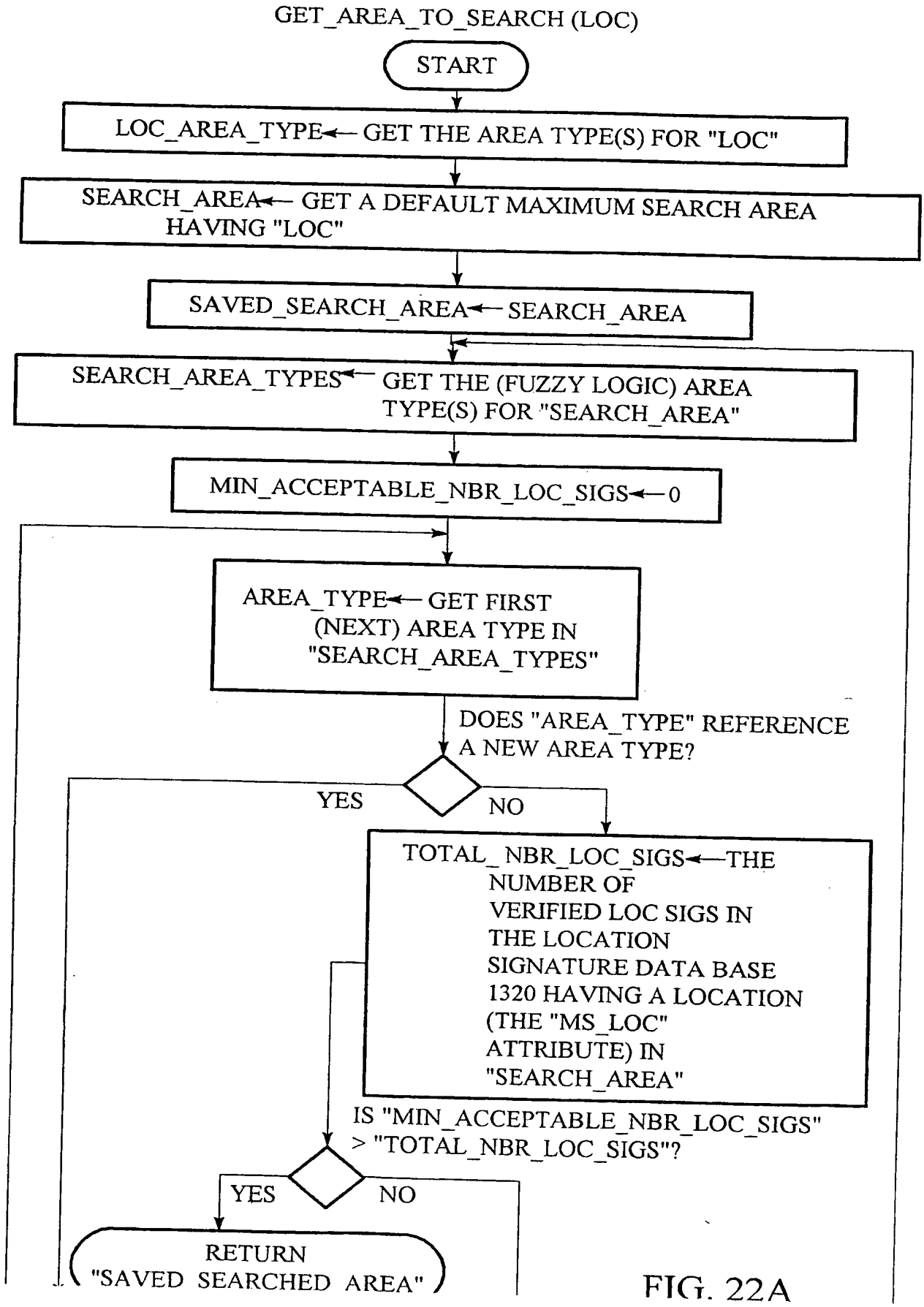

GET_AREA_TO_SEARCH (LOC)
START
LOC_AREA_TYPE← GET THE AREA TYPE(S) FOR "LOC"
SEARCH_AREA← GET A DEFAULT MAXIMUM SEARCH AREA HAVING "LOC"
SAVED_SEARCH_AREA← SEARCH_AREA
SEARCH_AREA_TYPES← GET THE (FUZZY LOGIC) AREA TYPE(S) FOR "SEARCH_AREA"
MIN_ACCEPTABLE_NBR_LOC_SIGS←0
AREA_TYPE← GET FIRST (NEXT) AREA TYPE IN "SEARCH_AREA_TYPES"
DOES "AREA_TYPE" REFERENCE A NEW AREA TYPE?
YES
NO
TOTAL_ NBR_LOC_SIGS←THE NUMBER OF VERIFIED LOC SIGS IN THE LOCATION SIGNATURE DATA BASE 1320 HAVING A LOCATION (THE "MS_LOC" ATTRIBUTE) IN "SEARCH_AREA"
IS "MIN_ACCEPTABLE_NBR_LOC_SIGS" > "TOTAL_NBR_LOC_SIGS"?
YES
NO
RETURN "SAVED SEARCHED AREA"

FIG. 22A

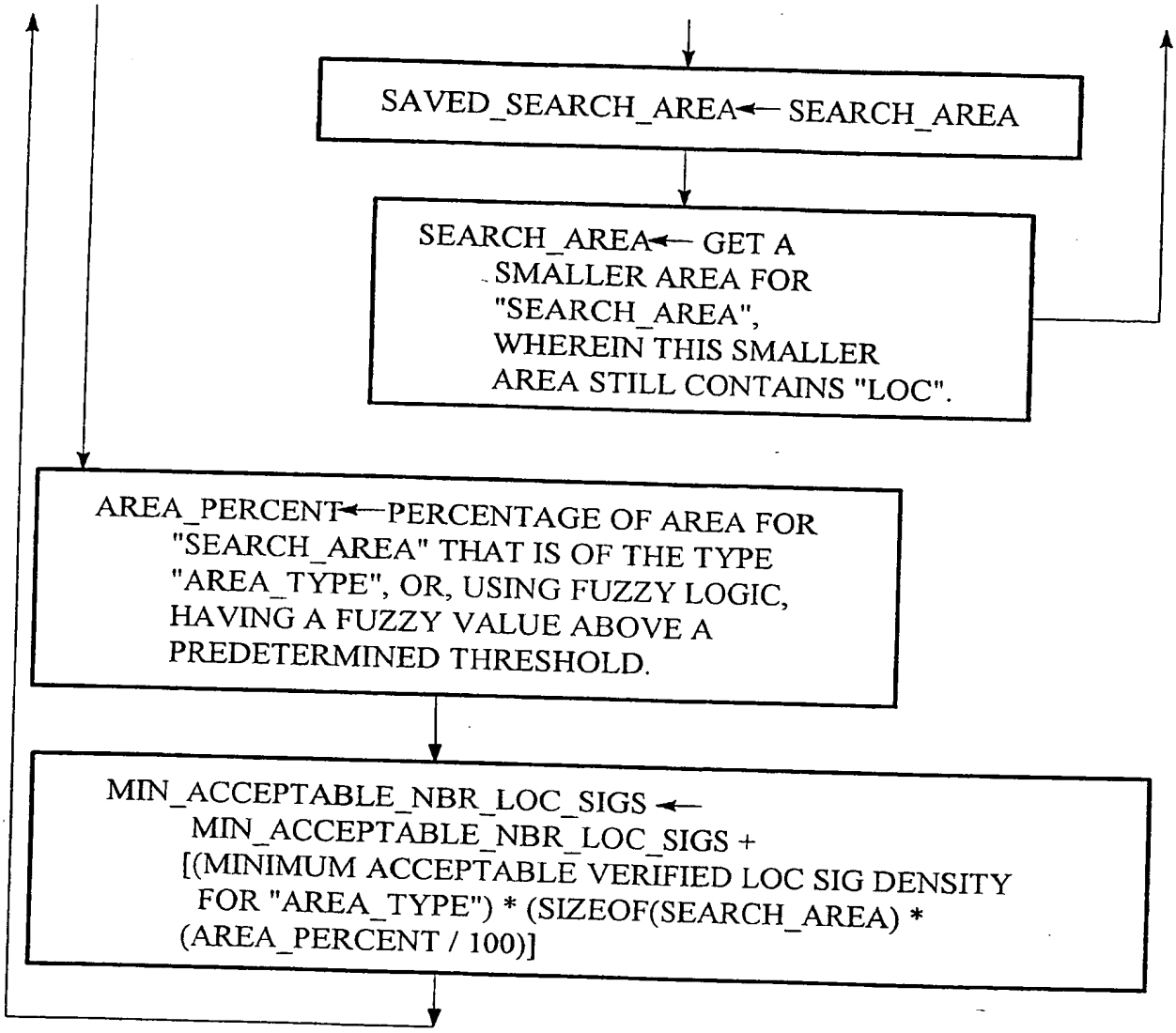

SAVED_SEARCH_AREA ← SEARCH_AREA
SEARCH_AREA ← GET A SMALLER AREA FOR "SEARCH_AREA", WHEREIN THIS SMALLER AREA STILL CONTAINS "LOC".
AREA_PERCENT ← PERCENTAGE OF AREA FOR "SEARCH_AREA" THAT IS OF THE TYPE "AREA_TYPE", OR, USING FUZZY LOGIC, HAVING A FUZZY VALUE ABOVE A PREDETERMINED THRESHOLD.
MIN_ACCEPTABLE_NBR_LOC_SIGS ← MIN_ACCEPTABLE_NBR_LOC_SIGS + [(MINIMUM ACCEPTABLE VERIFIED LOC SIG DENSITY FOR "AREA_TYPE") * (SIZEOF(SEARCH_AREA) * (AREA_PERCENT / 100)]

FIG. 22B

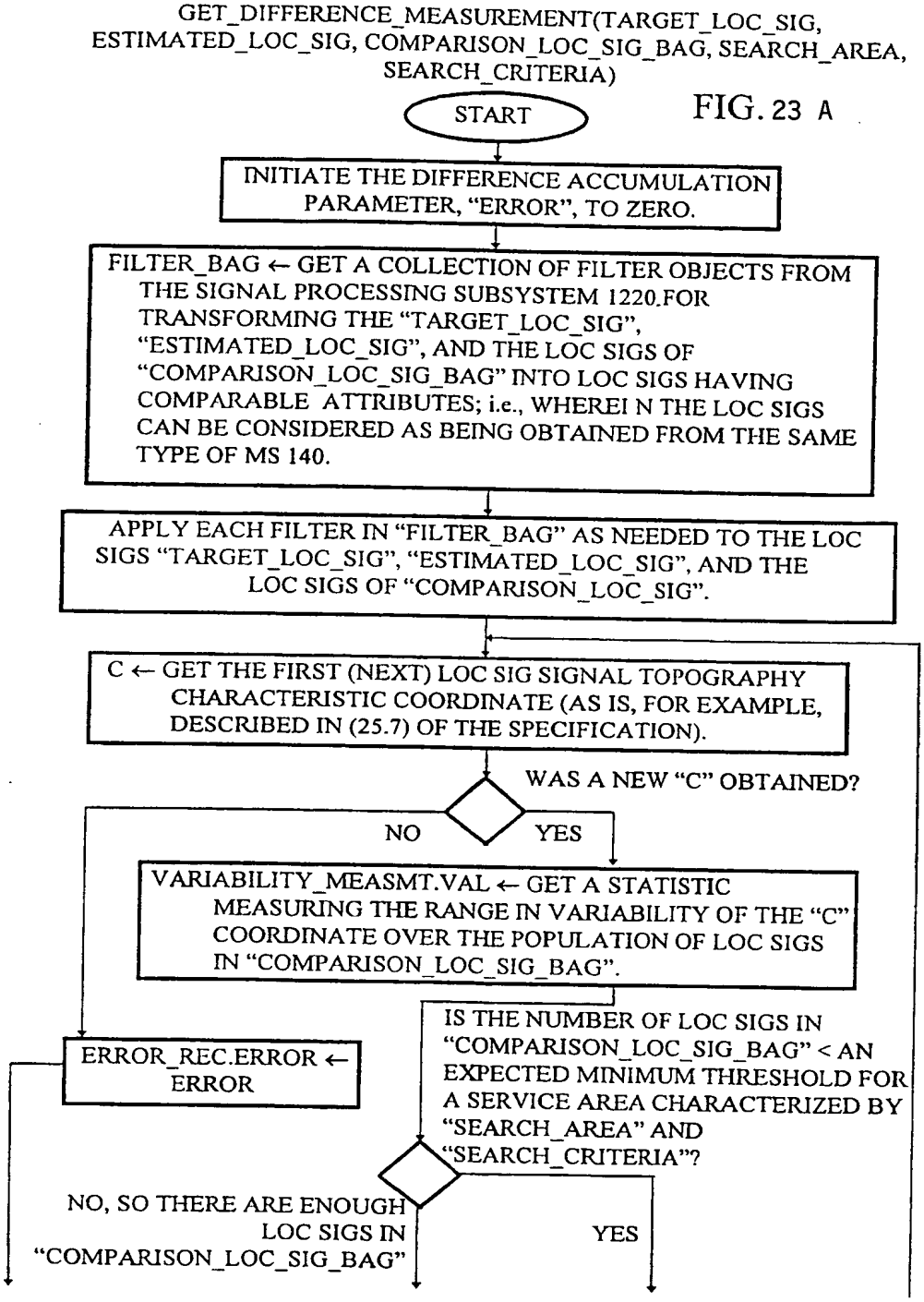


FIG. 23 A

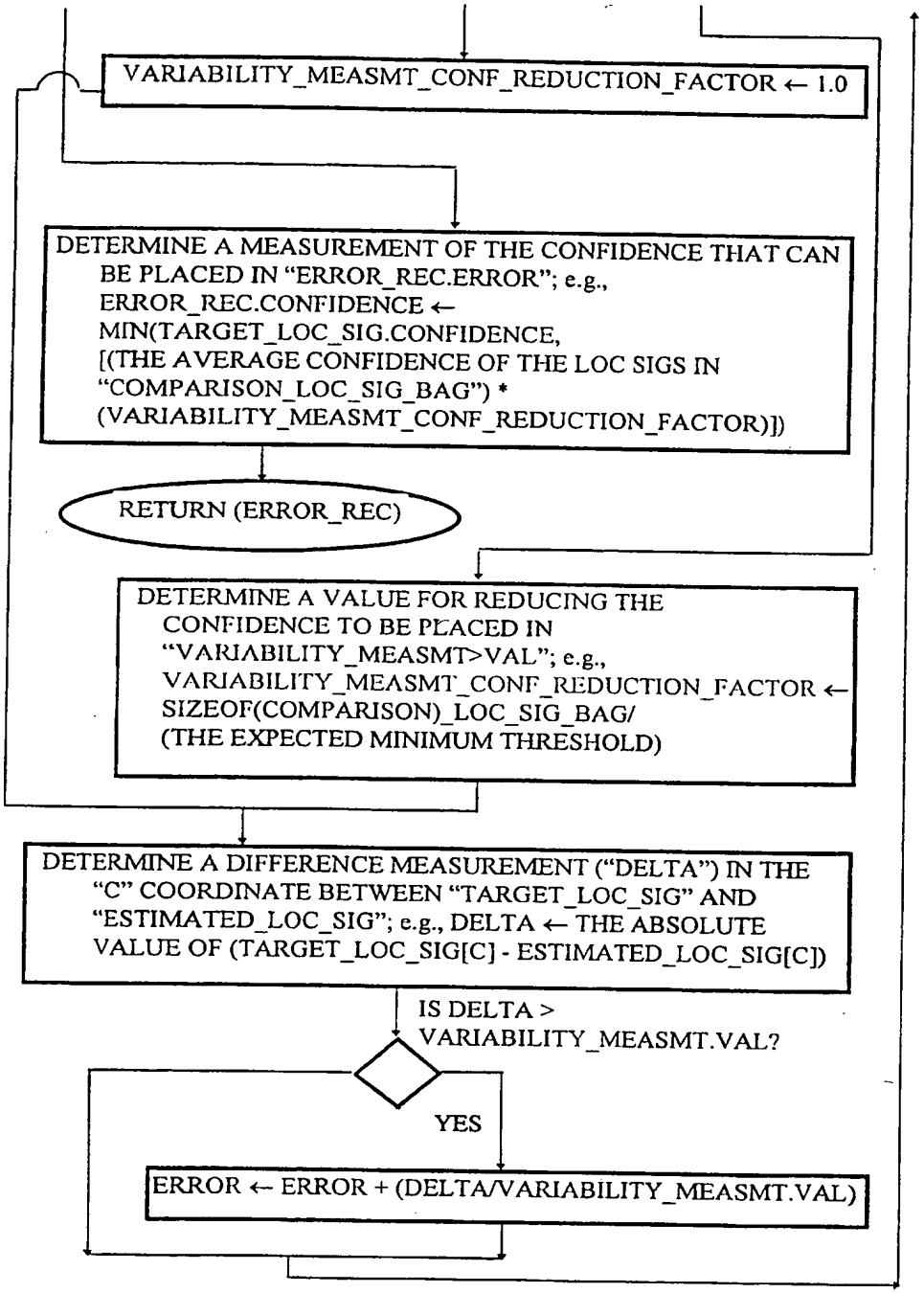

VARIABILITY_MEASMT_CONF_REDUCTION_FACTOR ← 1.0
DETERMINE A MEASUREMENT OF THE CONFIDENCE THAT CAN BE PLACED IN "ERROR_REC.ERROR"; e.g., ERROR_REC.CONFIDENCE ← MIN(TARGET_LOC_SIG.CONFIDENCE, [(THE AVERAGE CONFIDENCE OF THE LOC SIGS IN "COMPARISON_LOC_SIG_BAG") * (VARIABILITY_MEASMT_CONF_REDUCTION_FACTOR)])
RETURN (ERROR_REC)
DETERMINE A VALUE FOR REDUCING THE CONFIDENCE TO BE PLACED IN "VARIABILITY_MEASMT>VAL"; e.g., VARIABILITY_MEASMT_CONF_REDUCTION_FACTOR ← SIZEOF(COMPARISON)_LOC_SIG_BAG/ (THE EXPECTED MINIMUM THRESHOLD)
DETERMINE A DIFFERENCE MEASUREMENT ("DELTA") IN THE "C" COORDINATE BETWEEN "TARGET_LOC_SIG" AND "ESTIMATED_LOC_SIG"; e.g., DELTA ← THE ABSOLUTE VALUE OF (TARGET_LOC_SIG[C] - ESTIMATED_LOC_SIG[C])
IS DELTA > VARIABILITY_MEASMT.VAL?
YES
ERROR ← ERROR + (DELTA/VARIABILITY_MEASMT.VAL)

FIG. 23B

FIG. 24

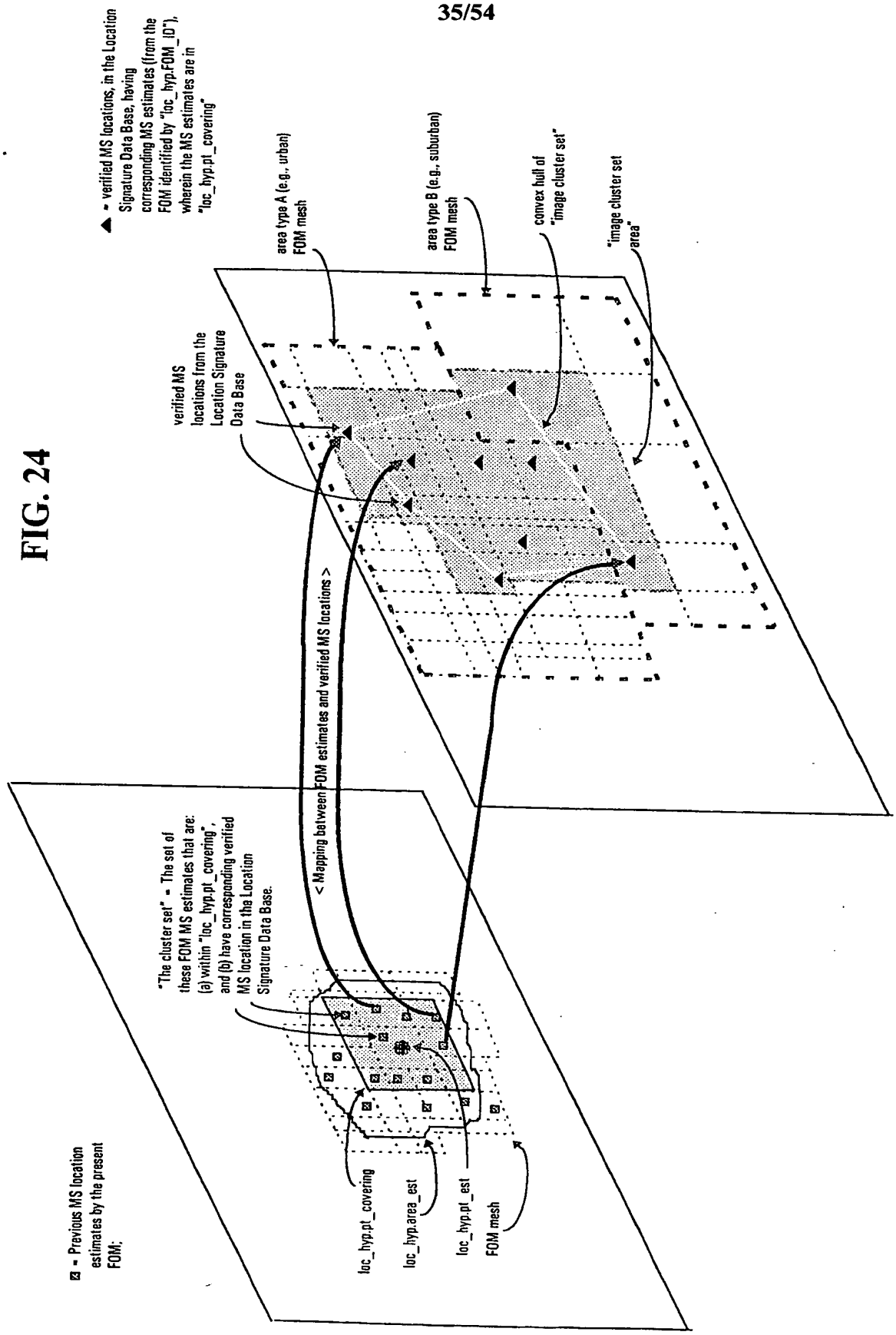
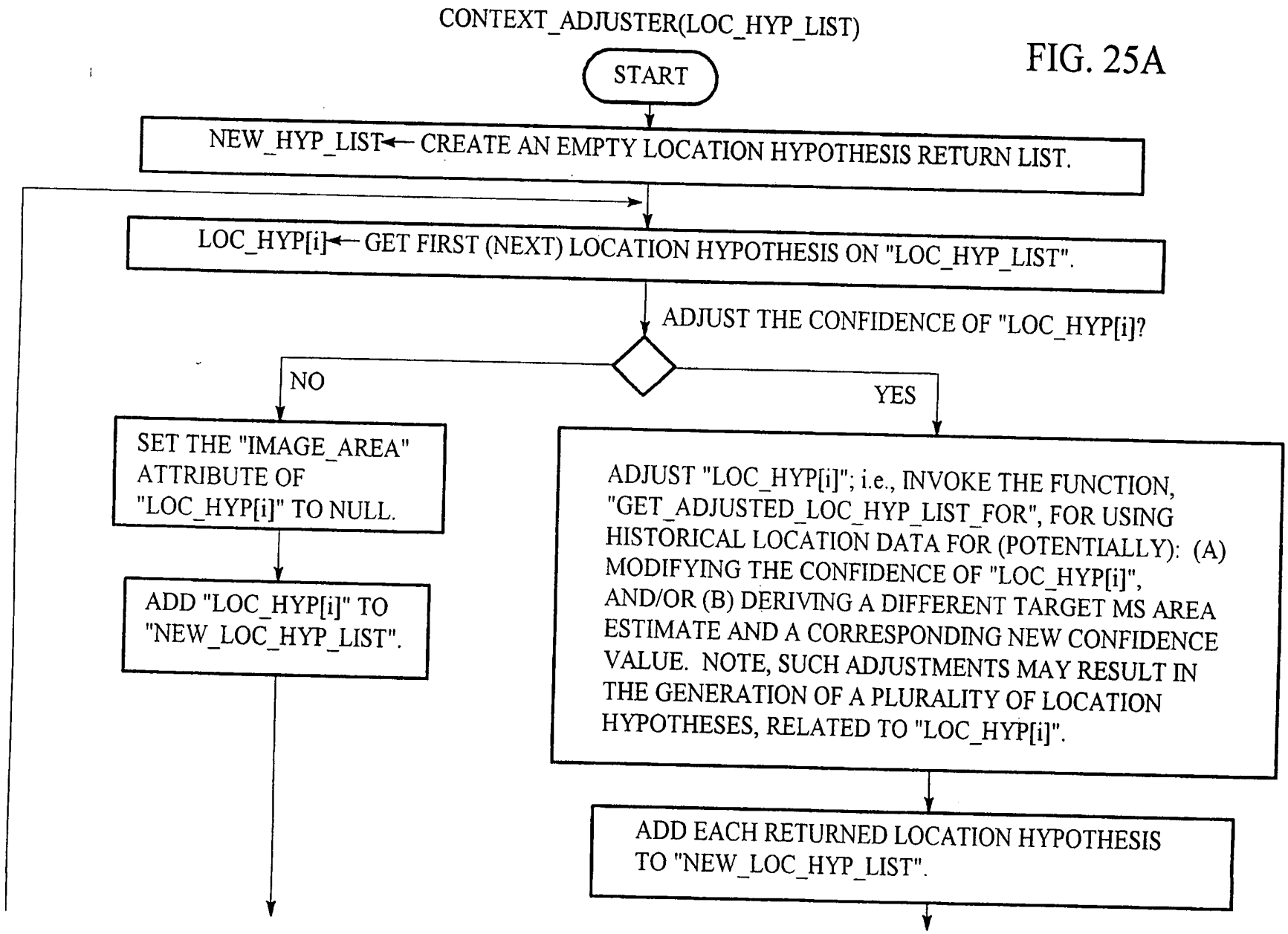

▲ = verified MS locations, in the Location Signature Data Base, having corresponding MS estimates (from the FOM identified by "loc_hyp.FOM_ID"), wherein the MS estimates are in "loc_hyp.pt_covering"
area type A (e.g., urban) FOM mesh
area type B (e.g., suburban) FOM mesh
convex hull of "image cluster set"
"image cluster set area"
verified MS locations from the Location Signature Data Base
< Mapping between FOM estimates and verified MS locations >
"The cluster set" = The set of these FOM MS estimates that are: (a) within "loc_hyp.pt_covering", and (b) have corresponding verified MS location in the Location Signature Data Base.
⊠ = Previous MS location estimates by the present FOM;
loc_hyp.pt_covering
loc_hyp.area_est
loc_hyp.pt_est
FOM mesh

FIG. 25A



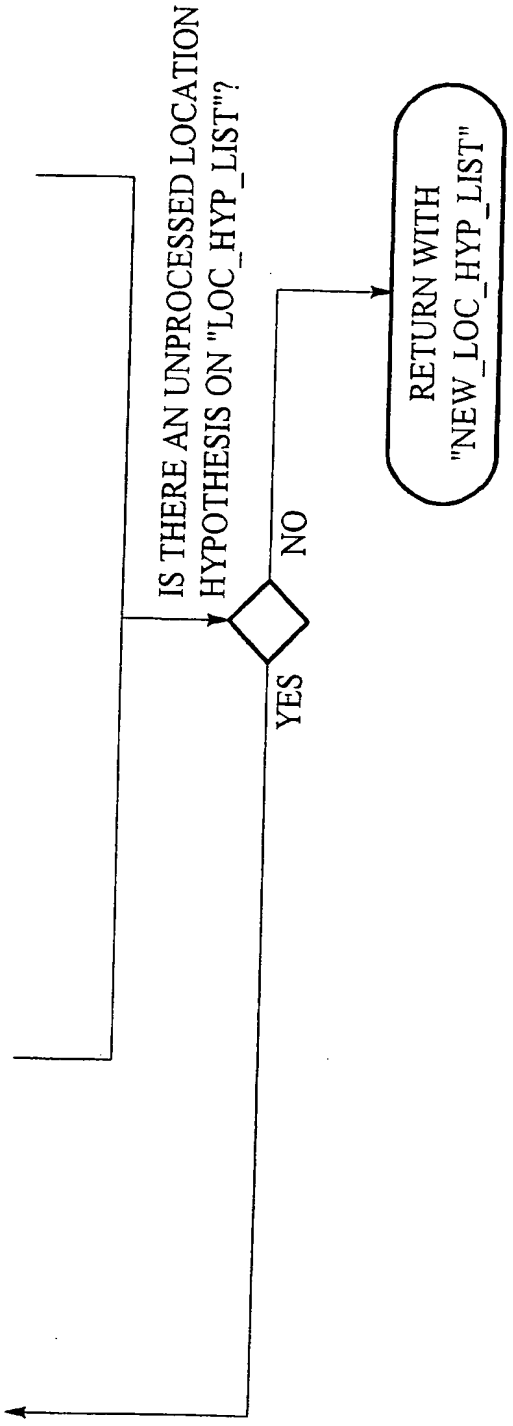

IS THERE AN UNPROCESSED LOCATION HYPOTHESIS ON "LOC_HYP_LIST"?
NO
YES
RETURN WITH "NEW_LOC_HYP_LIST"

FIG. 25B

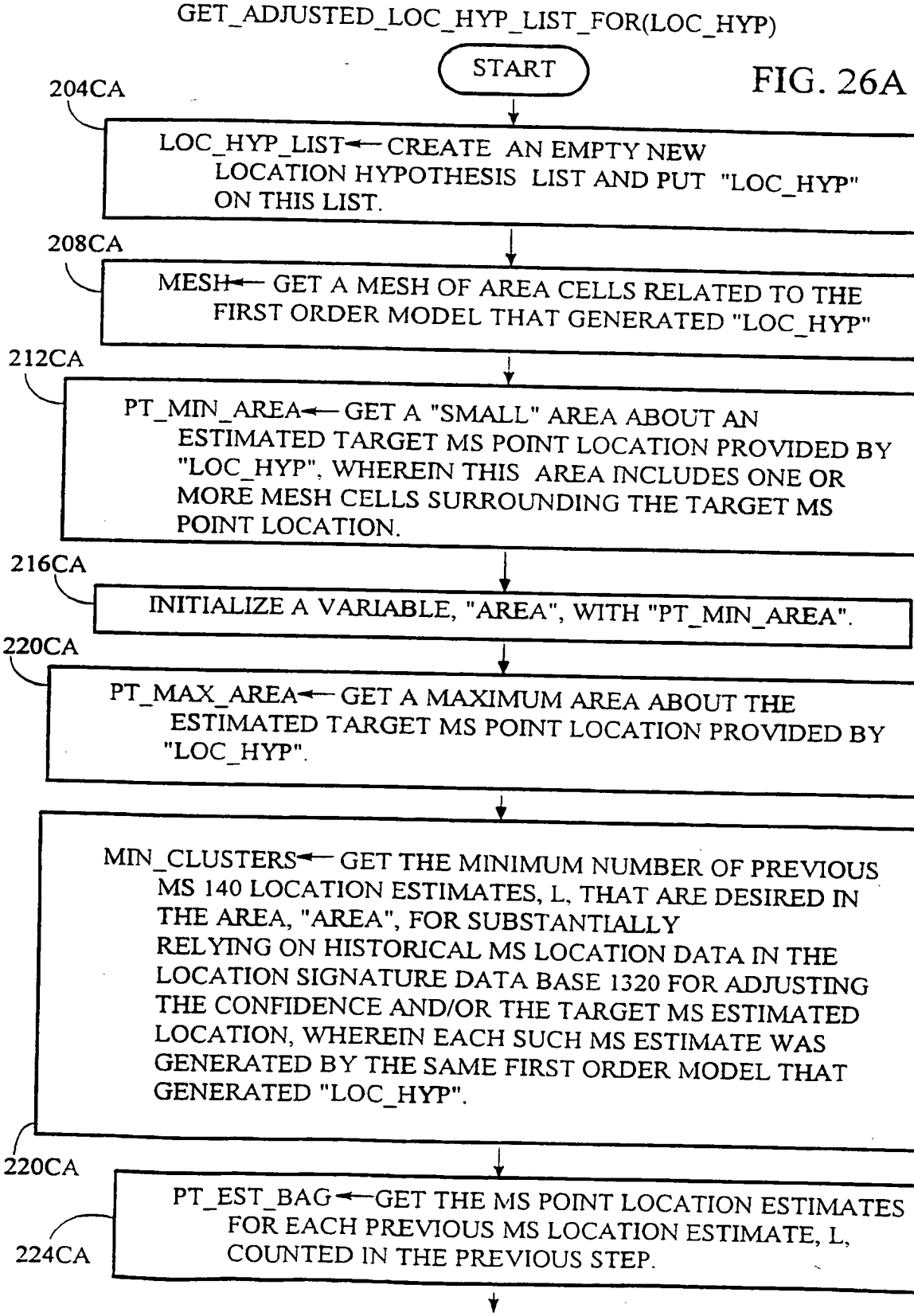

GET_ADJUSTED_LOC_HYP_LIST_FOR(LOC_HYP)
START
204CA
LOC_HYP_LIST ← CREATE AN EMPTY NEW LOCATION HYPOTHESIS LIST AND PUT "LOC_HYP" ON THIS LIST.
208CA
MESH ← GET A MESH OF AREA CELLS RELATED TO THE FIRST ORDER MODEL THAT GENERATED "LOC_HYP"
212CA
PT_MIN_AREA ← GET A "SMALL" AREA ABOUT AN ESTIMATED TARGET MS POINT LOCATION PROVIDED BY "LOC_HYP", WHEREIN THIS AREA INCLUDES ONE OR MORE MESH CELLS SURROUNDING THE TARGET MS POINT LOCATION.
216CA
INITIALIZE A VARIABLE, "AREA", WITH "PT_MIN_AREA".
220CA
PT_MAX_AREA ← GET A MAXIMUM AREA ABOUT THE ESTIMATED TARGET MS POINT LOCATION PROVIDED BY "LOC_HYP".
MIN_CLUSTERS ← GET THE MINIMUM NUMBER OF PREVIOUS MS 140 LOCATION ESTIMATES, L, THAT ARE DESIRED IN THE AREA, "AREA", FOR SUBSTANTIALLY RELYING ON HISTORICAL MS LOCATION DATA IN THE LOCATION SIGNATURE DATA BASE 1320 FOR ADJUSTING THE CONFIDENCE AND/OR THE TARGET MS ESTIMATED LOCATION, WHEREIN EACH SUCH MS ESTIMATE WAS GENERATED BY THE SAME FIRST ORDER MODEL THAT GENERATED "LOC_HYP".
220CA
PT_EST_BAG ← GET THE MS POINT LOCATION ESTIMATES FOR EACH PREVIOUS MS LOCATION ESTIMATE, L, COUNTED IN THE PREVIOUS STEP.
224CA

FIG. 26A

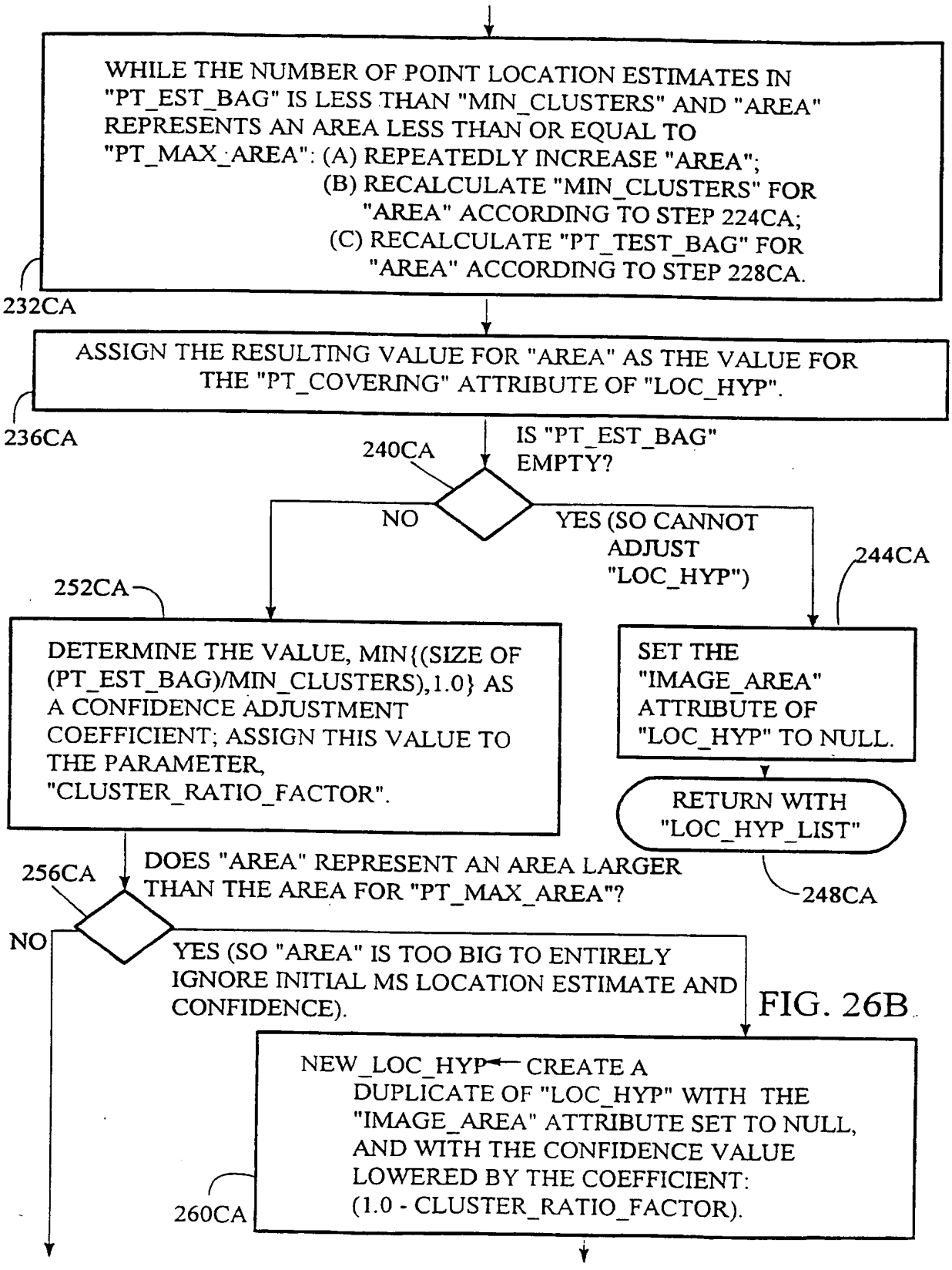

WHILE THE NUMBER OF POINT LOCATION ESTIMATES IN "PT_EST_BAG" IS LESS THAN "MIN_CLUSTERS" AND "AREA" REPRESENTS AN AREA LESS THAN OR EQUAL TO "PT_MAX_AREA": (A) REPEATEDLY INCREASE "AREA"; (B) RECALCULATE "MIN_CLUSTERS" FOR "AREA" ACCORDING TO STEP 224CA; (C) RECALCULATE "PT_TEST_BAG" FOR "AREA" ACCORDING TO STEP 228CA.
232CA
ASSIGN THE RESULTING VALUE FOR "AREA" AS THE VALUE FOR THE "PT_COVERING" ATTRIBUTE OF "LOC_HYP".
236CA
240CA
IS "PT_EST_BAG" EMPTY?
NO
YES (SO CANNOT ADJUST "LOC_HYP")
244CA
252CA
DETERMINE THE VALUE, MIN{(SIZE OF (PT_EST_BAG)/MIN_CLUSTERS),1.0} AS A CONFIDENCE ADJUSTMENT COEFFICIENT; ASSIGN THIS VALUE TO THE PARAMETER, "CLUSTER_RATIO_FACTOR".
SET THE "IMAGE_AREA" ATTRIBUTE OF "LOC_HYP" TO NULL.
RETURN WITH "LOC_HYP_LIST"
248CA
256CA
DOES "AREA" REPRESENT AN AREA LARGER THAN THE AREA FOR "PT_MAX_AREA"?
NO
YES (SO "AREA" IS TOO BIG TO ENTIRELY IGNORE INITIAL MS LOCATION ESTIMATE AND CONFIDENCE).
NEW_LOC_HYP ← CREATE A DUPLICATE OF "LOC_HYP" WITH THE "IMAGE_AREA" ATTRIBUTE SET TO NULL, AND WITH THE CONFIDENCE VALUE LOWERED BY THE COEFFICIENT: (1.0 - CLUSTER_RATIO_FACTOR).
260CA

FIG. 26B

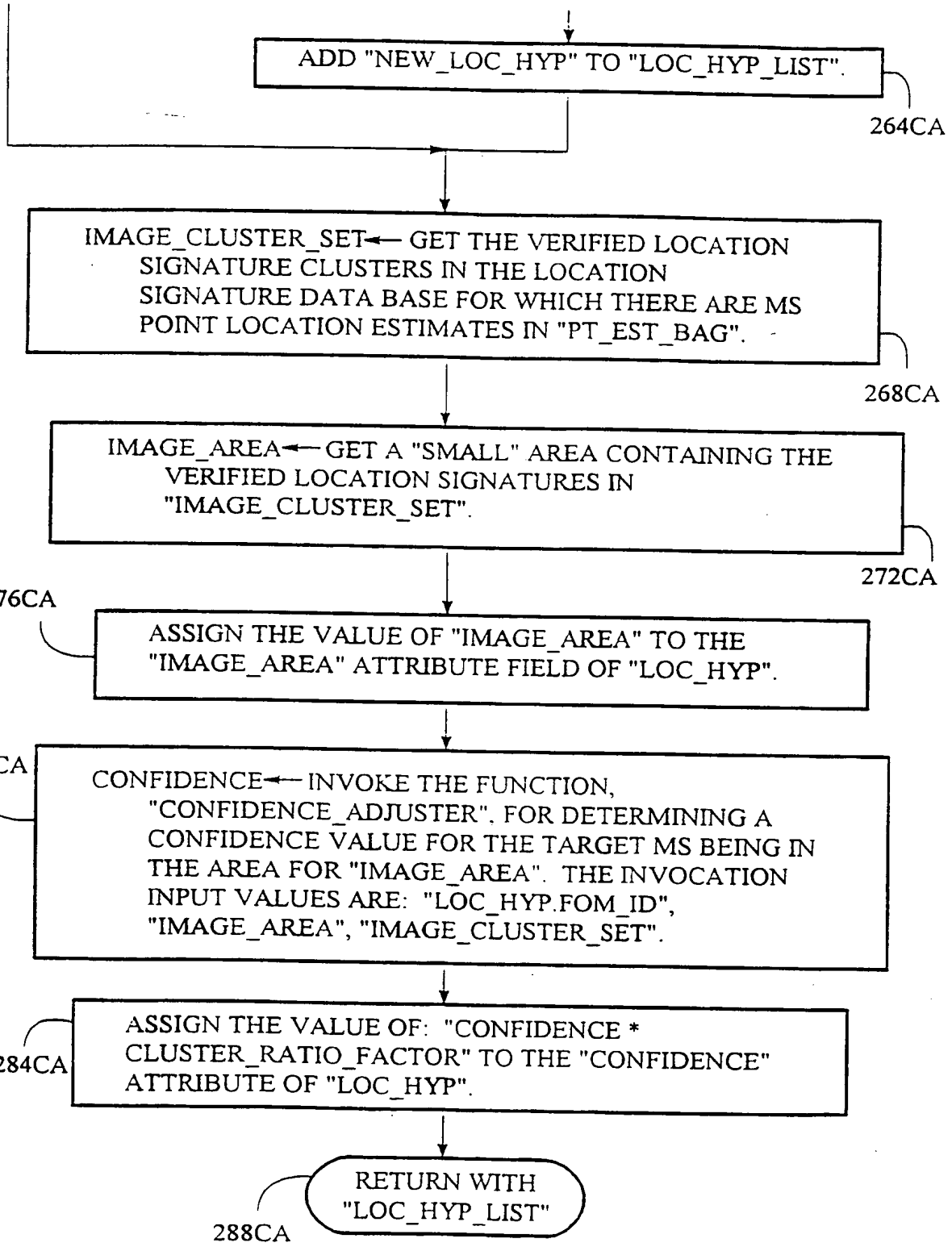

ADD "NEW_LOC_HYP" TO "LOC_HYP_LIST".
264CA
IMAGE_CLUSTER_SET← GET THE VERIFIED LOCATION SIGNATURE CLUSTERS IN THE LOCATION SIGNATURE DATA BASE FOR WHICH THERE ARE MS POINT LOCATION ESTIMATES IN "PT_EST_BAG".
268CA
IMAGE_AREA← GET A "SMALL" AREA CONTAINING THE VERIFIED LOCATION SIGNATURES IN "IMAGE_CLUSTER_SET".
272CA
276CA
ASSIGN THE VALUE OF "IMAGE_AREA" TO THE "IMAGE_AREA" ATTRIBUTE FIELD OF "LOC_HYP".
280CA
CONFIDENCE← INVOKE THE FUNCTION, "CONFIDENCE_ADJUSTER", FOR DETERMINING A CONFIDENCE VALUE FOR THE TARGET MS BEING IN THE AREA FOR "IMAGE_AREA". THE INVOCATION INPUT VALUES ARE: "LOC_HYP.FOM_ID", "IMAGE_AREA", "IMAGE_CLUSTER_SET".
284CA
ASSIGN THE VALUE OF: "CONFIDENCE * CLUSTER_RATIO_FACTOR" TO THE "CONFIDENCE" ATTRIBUTE OF "LOC_HYP".
RETURN WITH "LOC_HYP_LIST"
288CA

FIG. 26C

WO 98/10307

CONFIDENCE_ADJUSTER(FOM_ID,IMAGE_AREA,IMAGE_CLUSTER_SET)

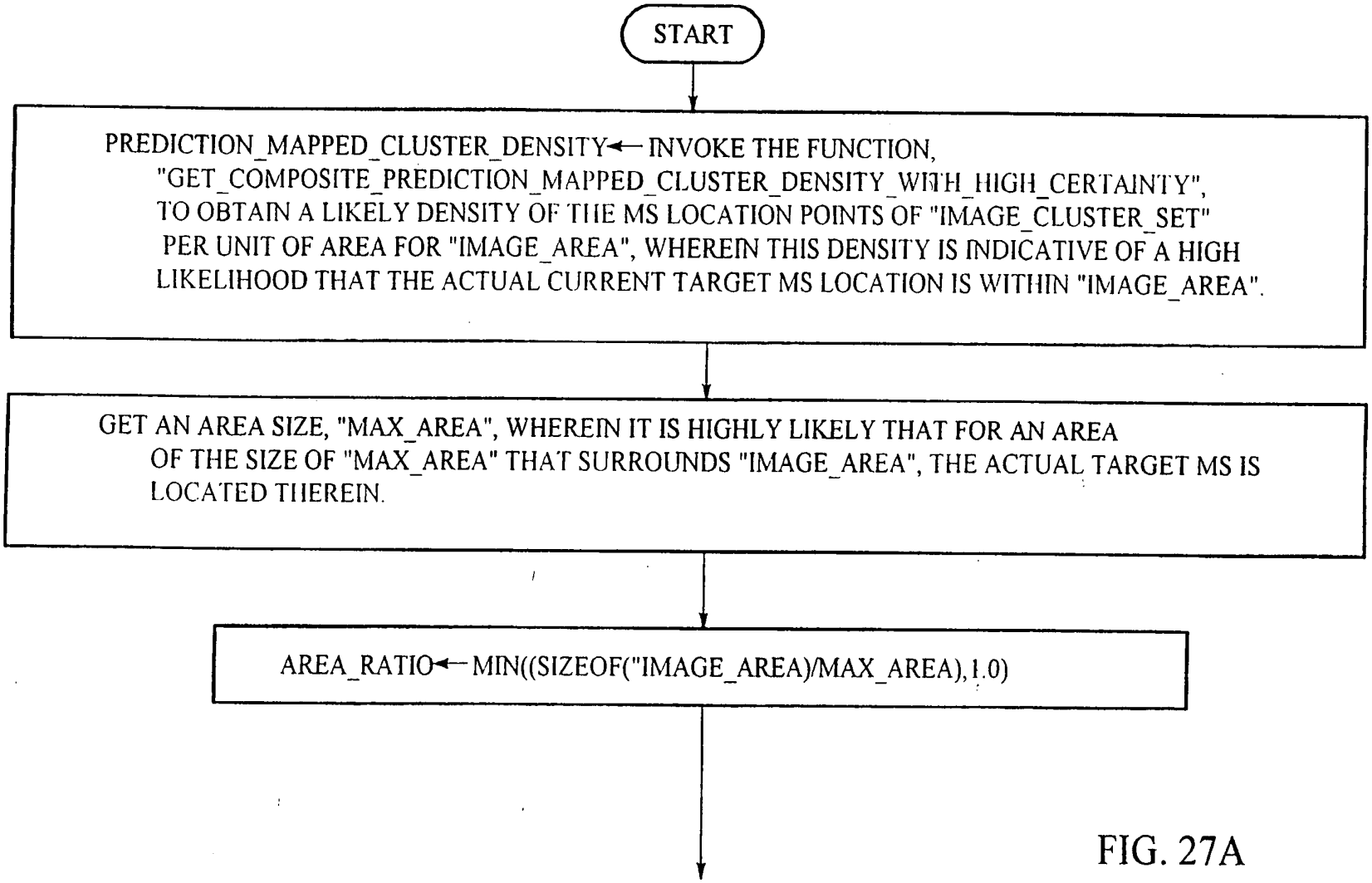


FIG. 27A

09/194367
PCT/US97/15892

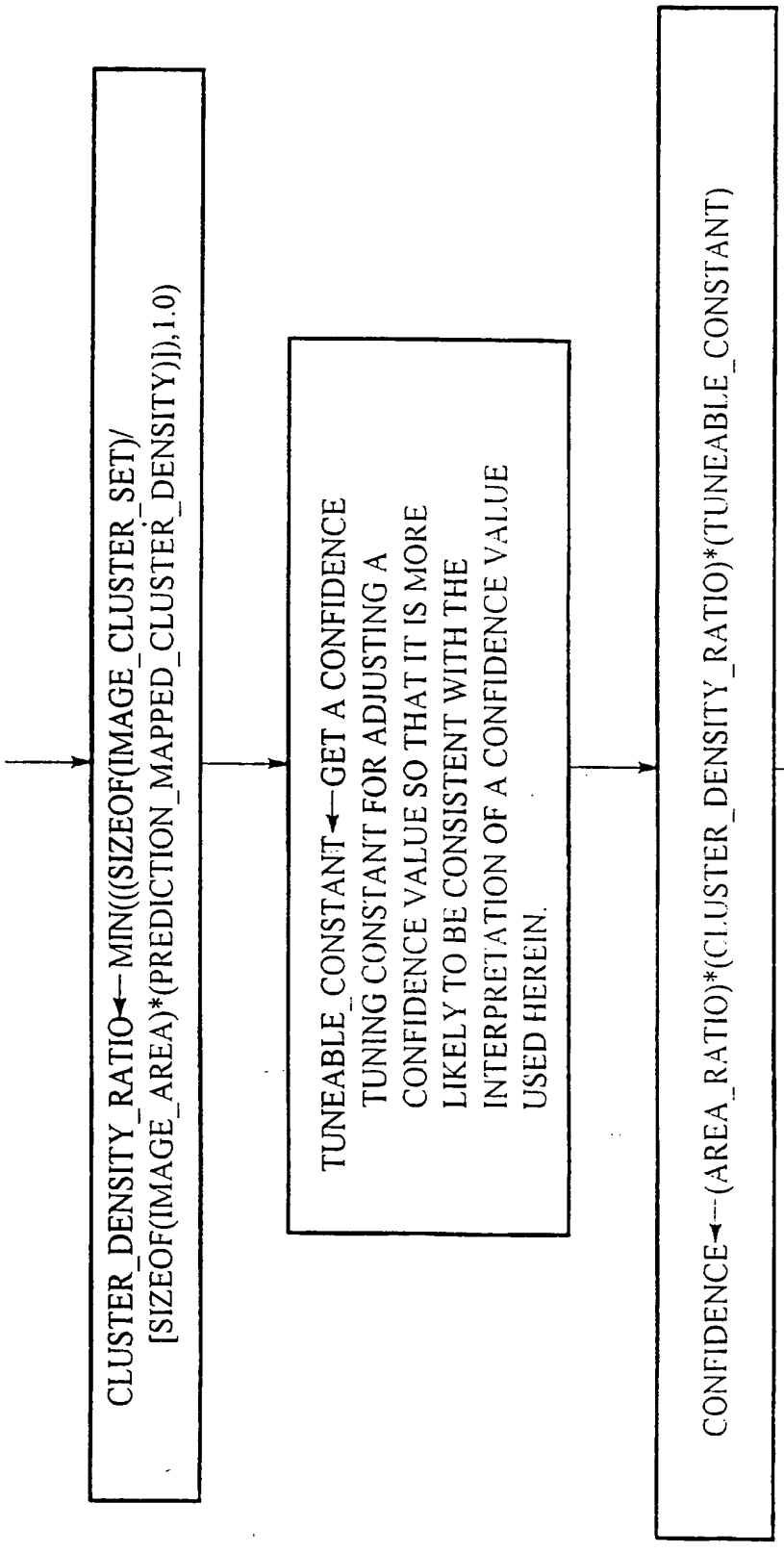
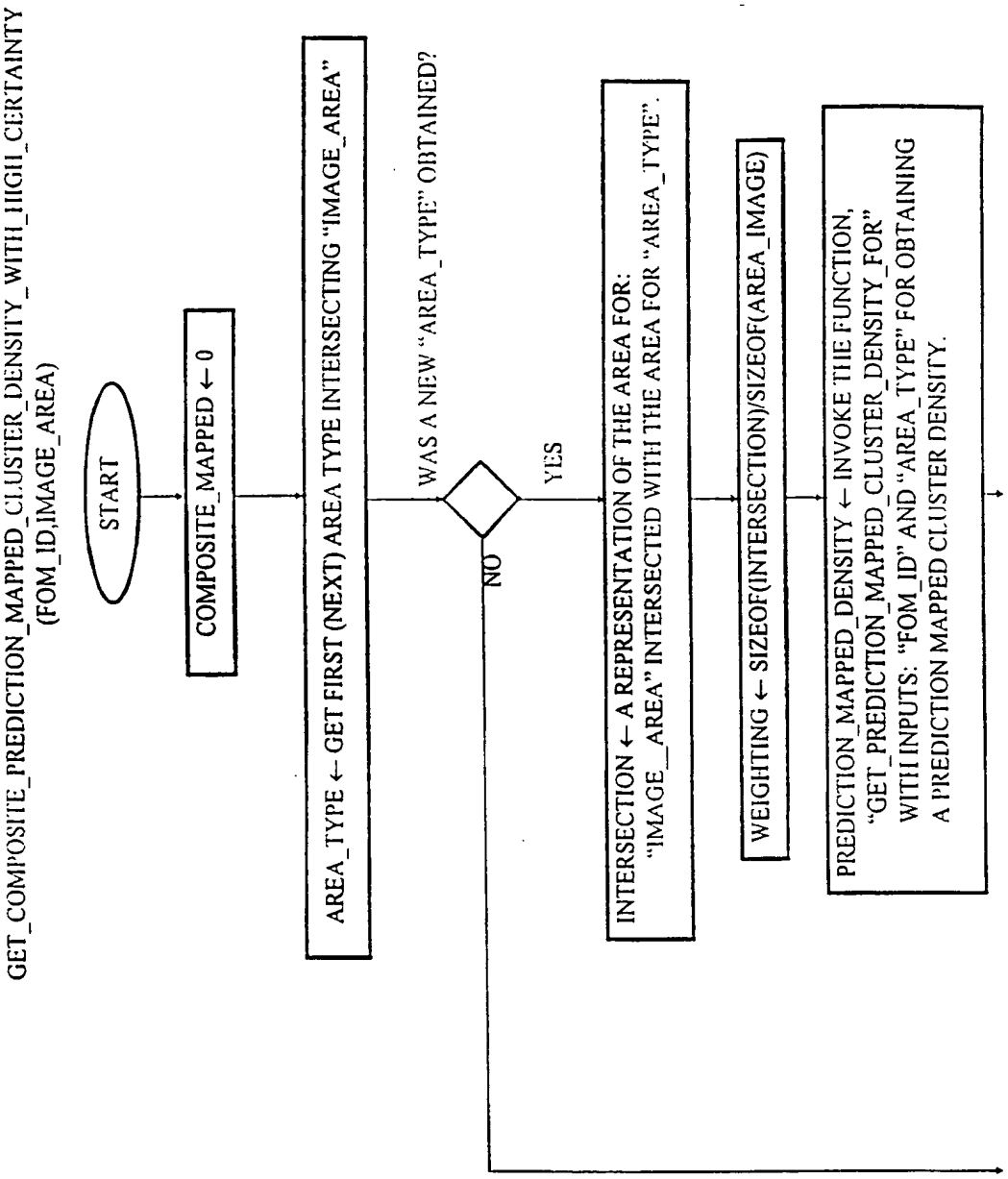

CLUSTER_DENSITY_RATIO←MIN(((SIZEOF(IMAGE_CLUSTER_SET)/
[SIZEOF(IMAGE_AREA)*(PREDICTION_MAPPED_CLUSTER_DENSITY)]),1.0)
TUNEABLE_CONSTANT←GET A CONFIDENCE
TUNING CONSTANT FOR ADJUSTING A
CONFIDENCE VALUE SO THAT IT IS MORE
LIKELY TO BE CONSISTENT WITH THE
INTERPRETATION OF A CONFIDENCE VALUE
USED HEREIN.
CONFIDENCE←(AREA_RATIO)*(CLUSTER_DENSITY_RATIO)*(TUNEABLE_CONSTANT)
RETURN(CONFIDENCE)

FIG. 27B

Fig. 28 A


GET_COMPOSITE_PREDICTION_MAPPED_CLUSTER_DENSITY_WITH_HIGH_CERTAINTY
(FOM_ID,IMAGE_AREA)
START
COMPOSITE_MAPPED ← 0
AREA_TYPE ← GET FIRST (NEXT) AREA TYPE INTERSECTING "IMAGE_AREA"
WAS A NEW "AREA_TYPE" OBTAINED?
YES
NO
INTERSECTION ← A REPRESENTATION OF THE AREA FOR:
"IMAGE_AREA" INTERSECTED WITH THE AREA FOR "AREA_TYPE".
WEIGHTING ← SIZEOF(INTERSECTION)/SIZEOF(AREA_IMAGE)
PREDICTION_MAPPED_DENSITY ← INVOKE THE FUNCTION,
"GET_PREDICTION_MAPPED_CLUSTER_DENSITY_FOR"
WITH INPUTS: "FOM_ID" AND "AREA_TYPE" FOR OBTAINING
A PREDICTION MAPPED CLUSTER DENSITY.

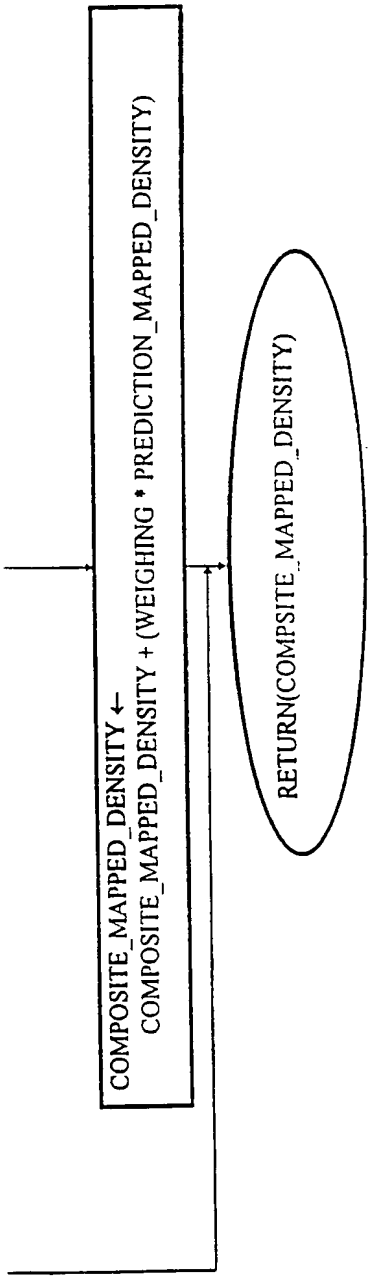

COMPOSITE_MAPPED_DENSITY ←
COMPOSITE_MAPPED_DENSITY + (WEIGHING * PREDICTION_MAPPED_DENSITY)
RETURN(COMPSITE_MAPPED_DENSITY)

Fig.28B

GET_PREDICTION_MAPPED_CLUSTER_DENSITY_FOR(FOM_ID,AREA_TYPE)

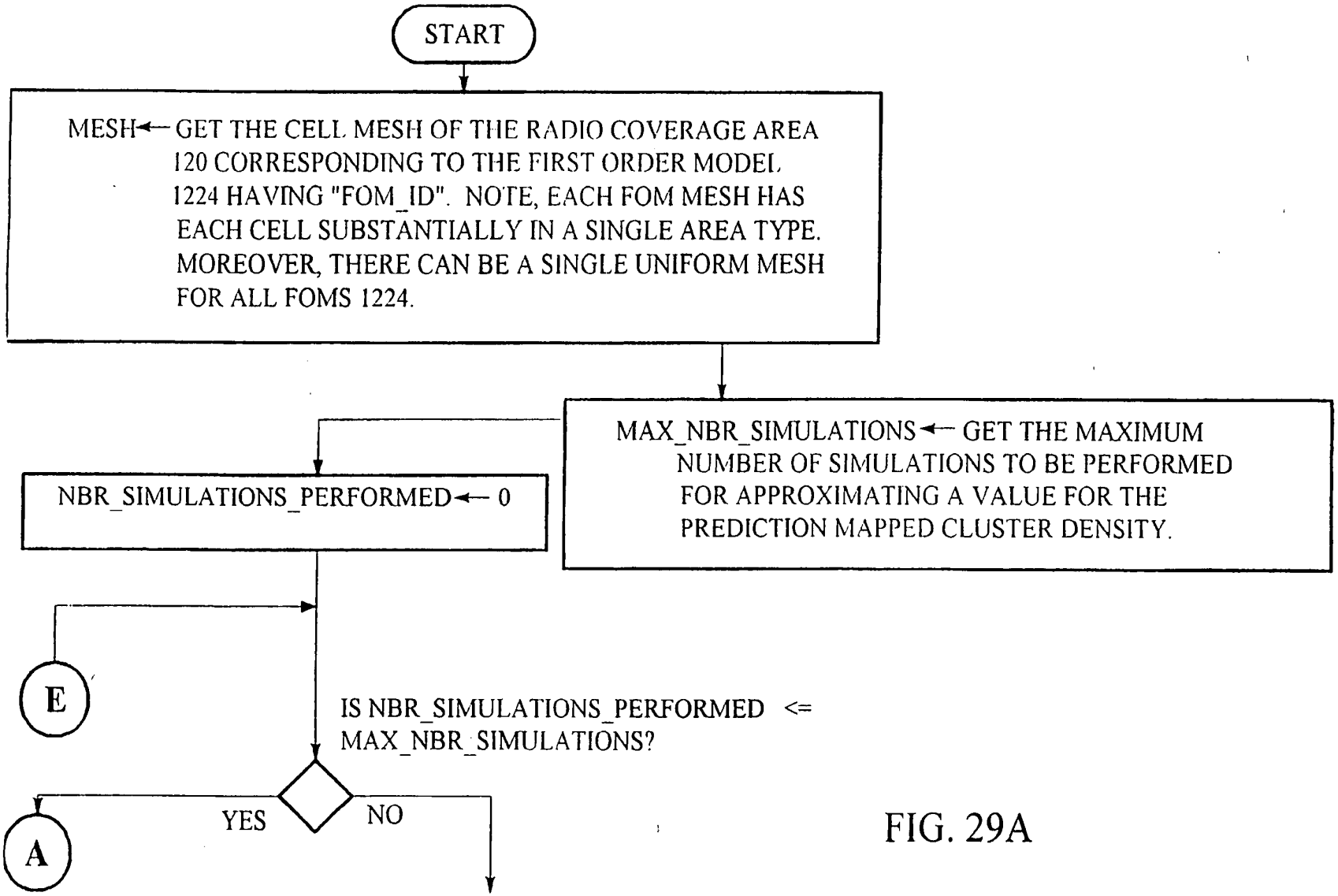


FIG. 29A

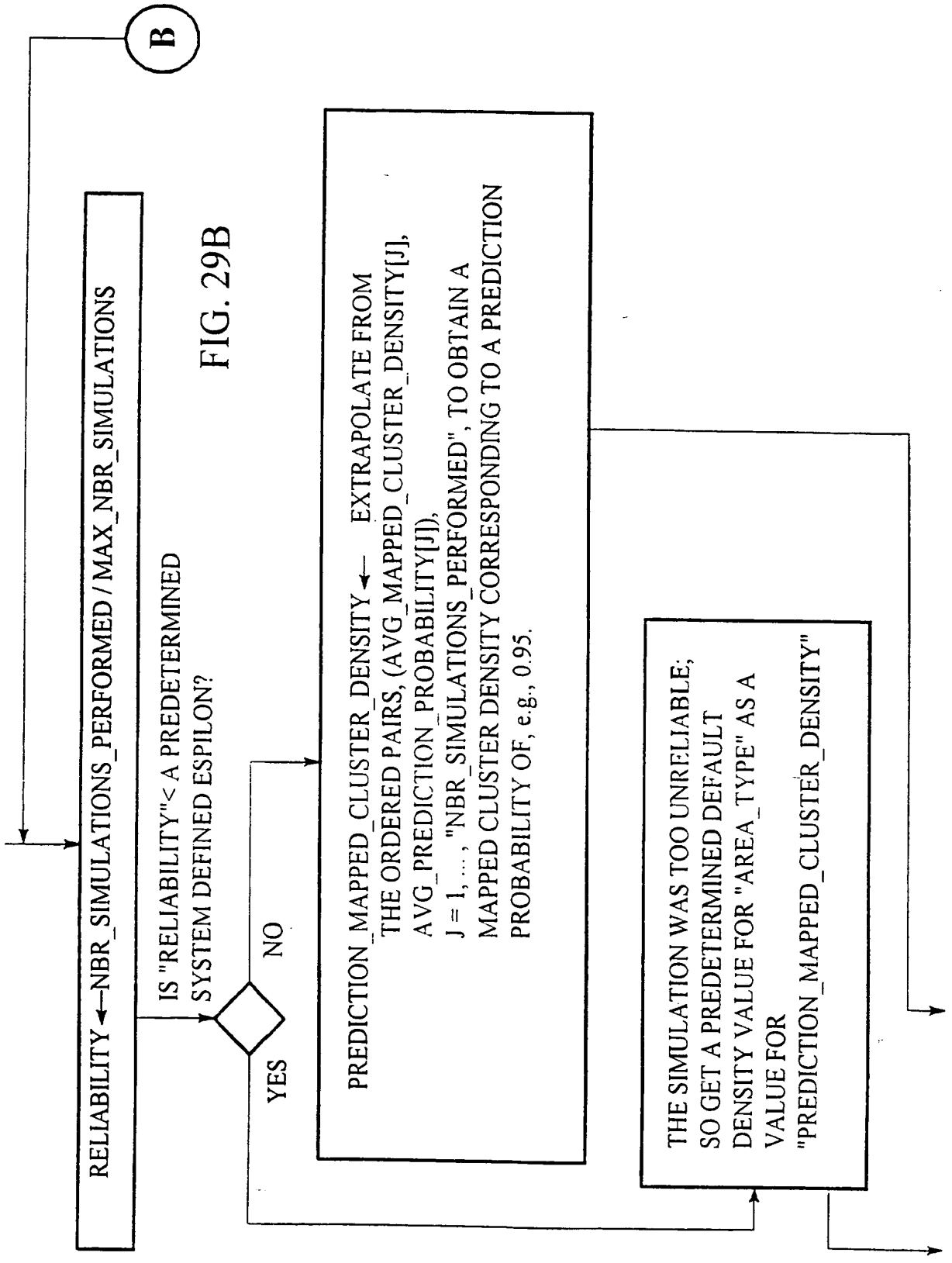

B
RELIABILITY ← NBR_SIMULATIONS_PERFORMED / MAX_NBR_SIMULATIONS
IS "RELIABILITY" < A PREDETERMINED SYSTEM DEFINED ESPILON?
NO
YES
PREDICTION_MAPPED_CLUSTER_DENSITY ← EXTRAPOLATE FROM THE ORDERED PAIRS, (AVG_MAPPED_CLUSTER_DENSITY[J], AVG_PREDICTION_PROBABILITY[J]), J = 1, ... , "NBR_SIMULATIONS_PERFORMED", TO OBTAIN A MAPPED CLUSTER DENSITY CORRESPONDING TO A PREDICTION PROBABILITY OF, e.g., 0.95.
THE SIMULATION WAS TOO UNRELIABLE; SO GET A PREDETERMINED DEFAULT DENSITY VALUE FOR "AREA_TYPE" AS A VALUE FOR "PREDICTION_MAPPED_CLUSTER_DENSITY"

FIG. 29B

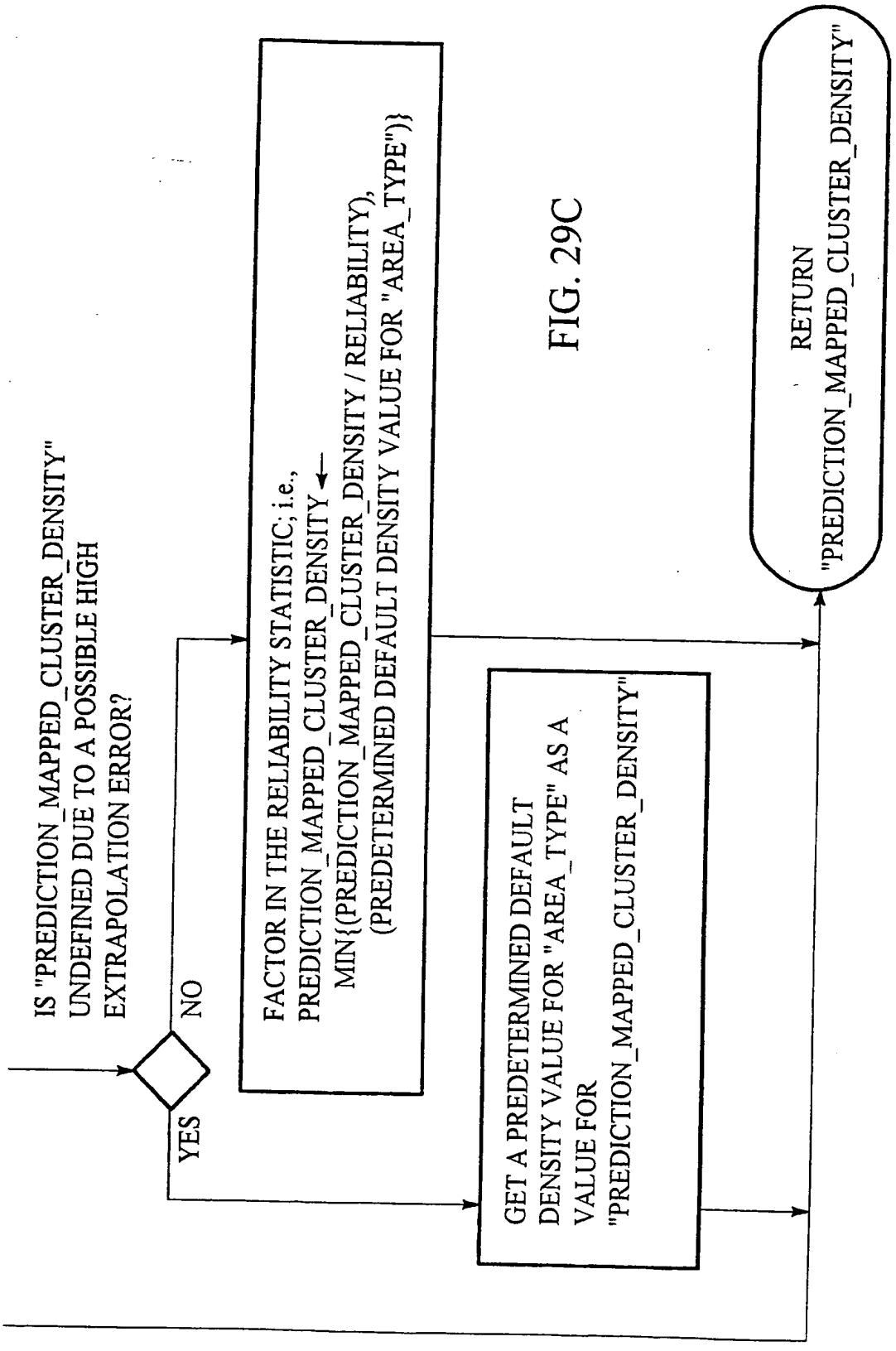

IS "PREDICTION_MAPPED_CLUSTER_DENSITY" UNDEFINED DUE TO A POSSIBLE HIGH EXTRAPOLATION ERROR?
NO
YES
FACTOR IN THE RELIABILITY STATISTIC; i.e., PREDICTION_MAPPED_CLUSTER_DENSITY ← MIN{(PREDICTION_MAPPED_CLUSTER_DENSITY / RELIABILITY), (PREDETERMINED DEFAULT DENSITY VALUE FOR "AREA_TYPE")}
GET A PREDETERMINED DEFAULT DENSITY VALUE FOR "AREA_TYPE" AS A VALUE FOR "PREDICTION_MAPPED_CLUSTER_DENSITY"
RETURN "PREDICTION_MAPPED_CLUSTER_DENSITY"

FIG. 29C

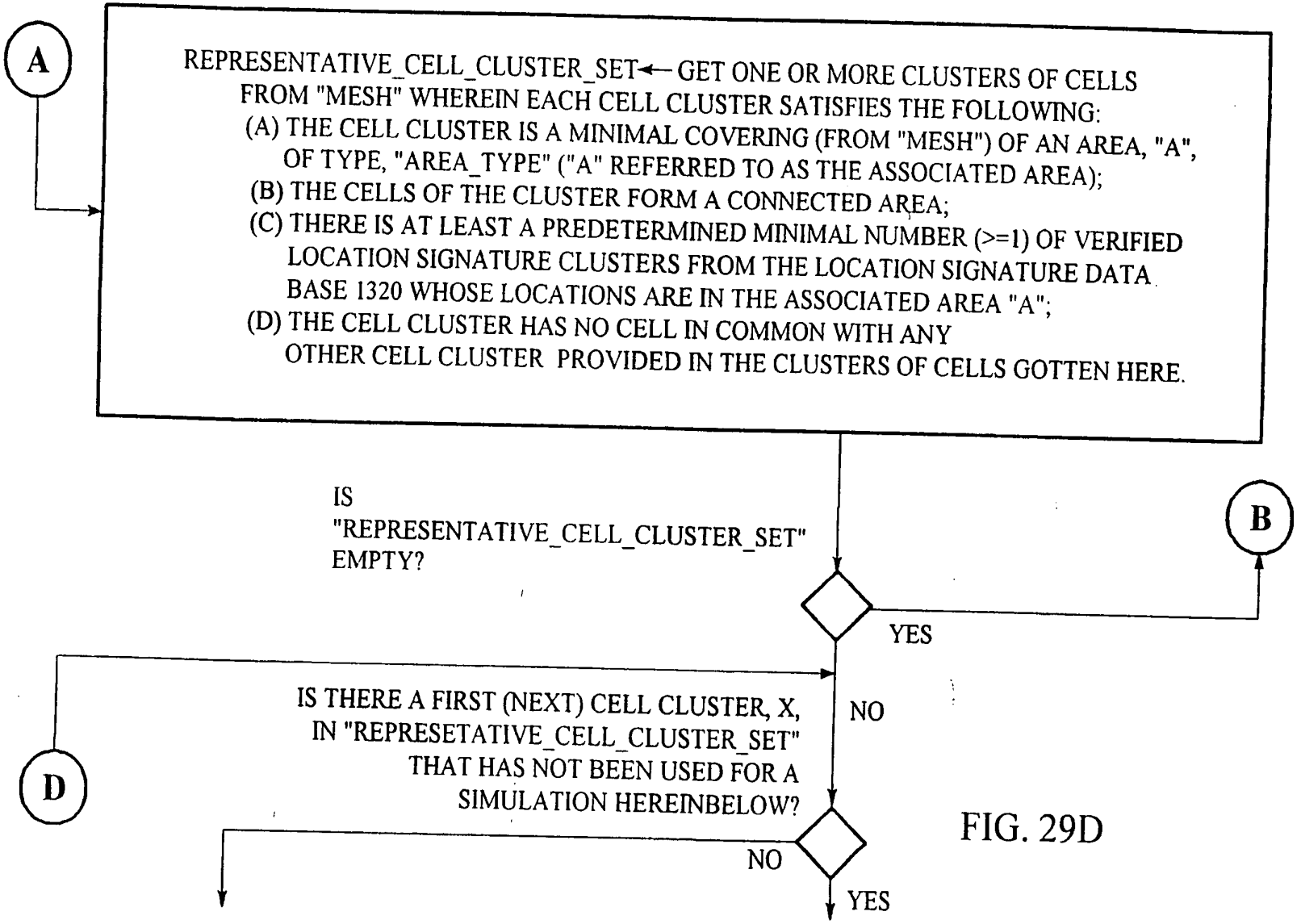


FIG. 29D

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FIG. 29E

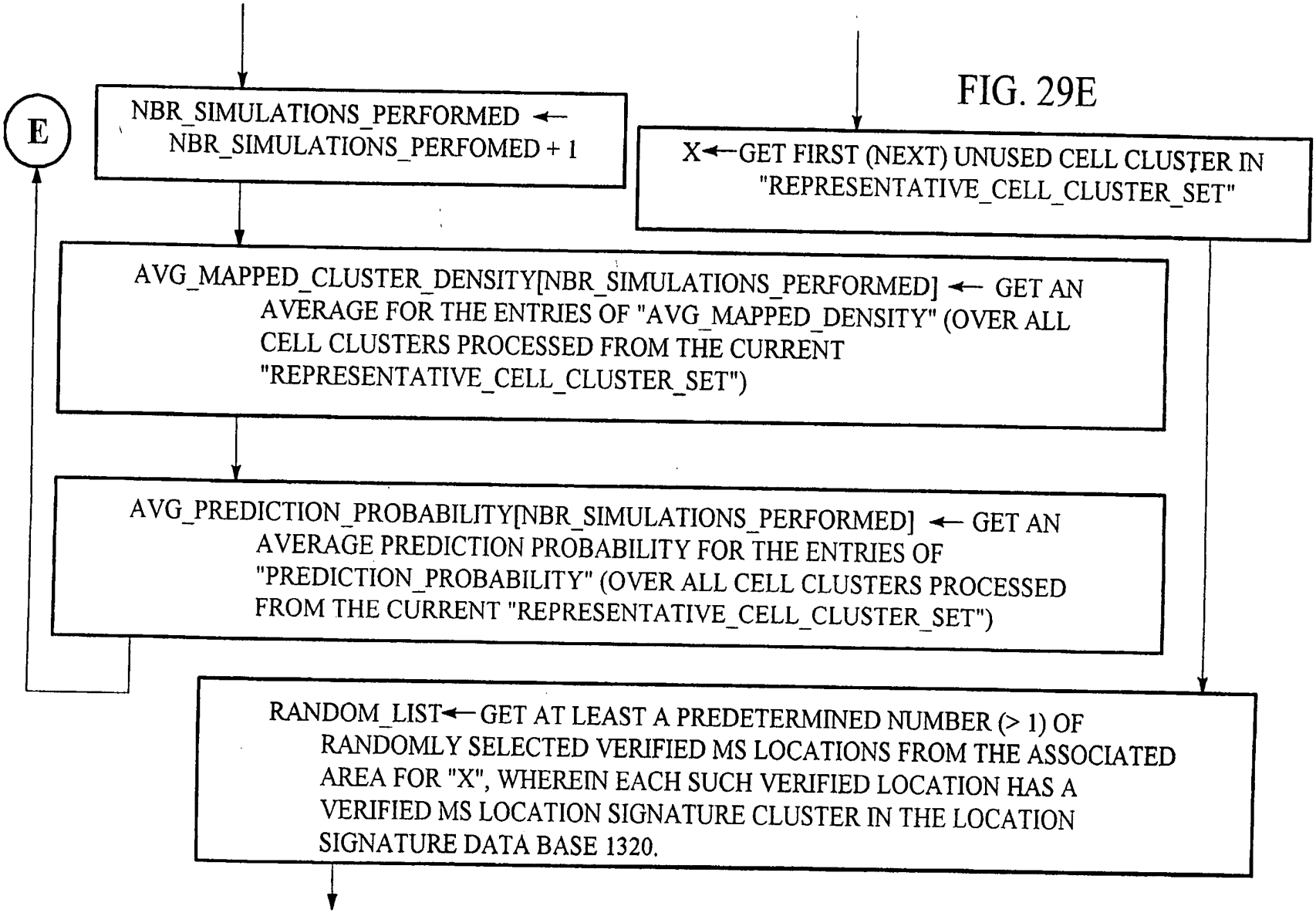
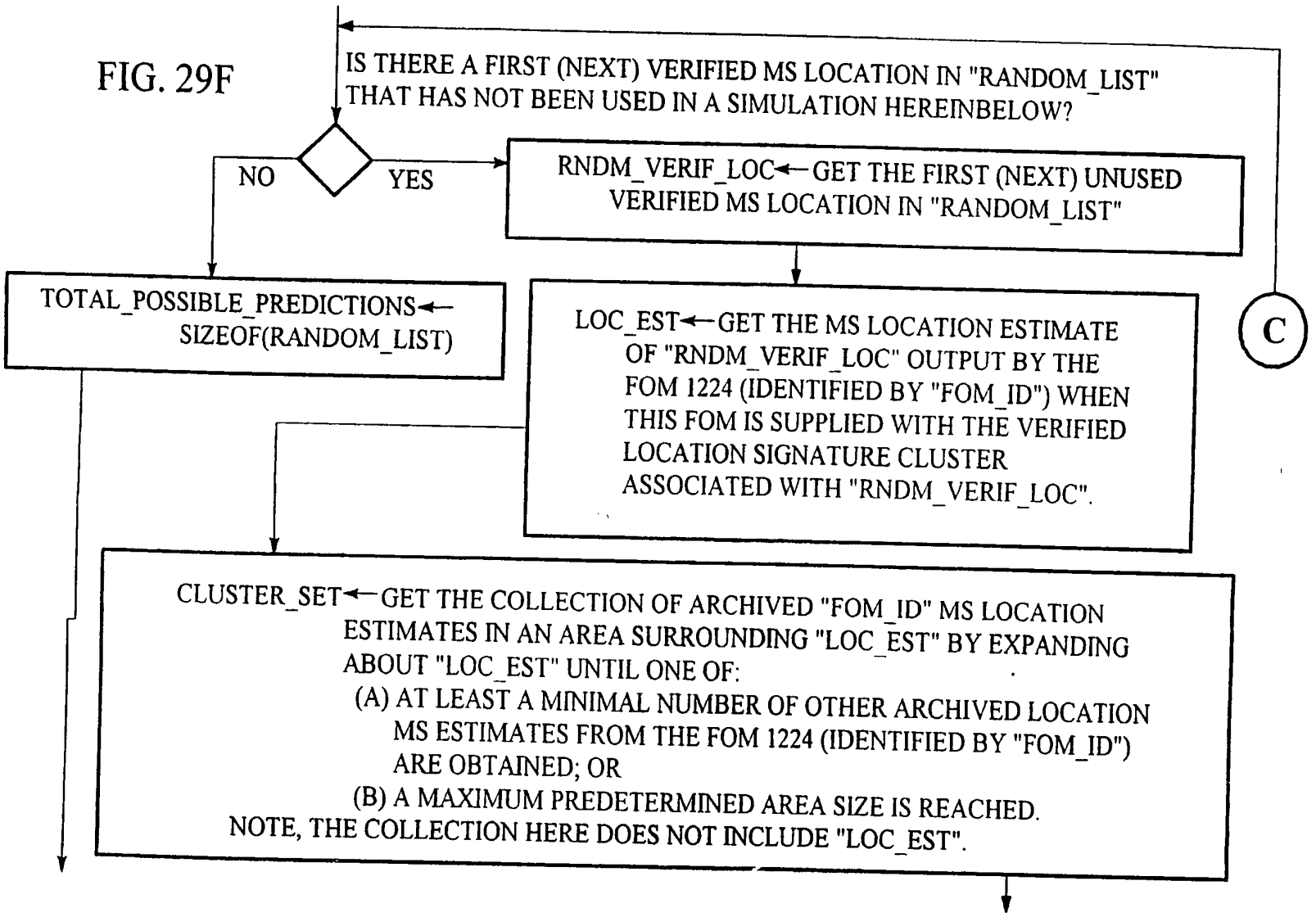

E
NBR_SIMULATIONS_PERFORMED ← NBR_SIMULATIONS_PERFOMED + 1
X←GET FIRST (NEXT) UNUSED CELL CLUSTER IN "REPRESENTATIVE_CELL_CLUSTER_SET"
AVG_MAPPED_CLUSTER_DENSITY[NBR_SIMULATIONS_PERFORMED] ← GET AN AVERAGE FOR THE ENTRIES OF "AVG_MAPPED_DENSITY" (OVER ALL CELL CLUSTERS PROCESSED FROM THE CURRENT "REPRESENTATIVE_CELL_CLUSTER_SET")
AVG_PREDICTION_PROBABILITY[NBR_SIMULATIONS_PERFORMED] ← GET AN AVERAGE PREDICTION PROBABILITY FOR THE ENTRIES OF "PREDICTION_PROBABILITY" (OVER ALL CELL CLUSTERS PROCESSED FROM THE CURRENT "REPRESENTATIVE_CELL_CLUSTER_SET")
RANDOM_LIST←GET AT LEAST A PREDETERMINED NUMBER (> 1) OF RANDOMLY SELECTED VERIFIED MS LOCATIONS FROM THE ASSOCIATED AREA FOR "X", WHEREIN EACH SUCH VERIFIED LOCATION HAS A VERIFIED MS LOCATION SIGNATURE CLUSTER IN THE LOCATION SIGNATURE DATA BASE 1320.

FIG. 29F



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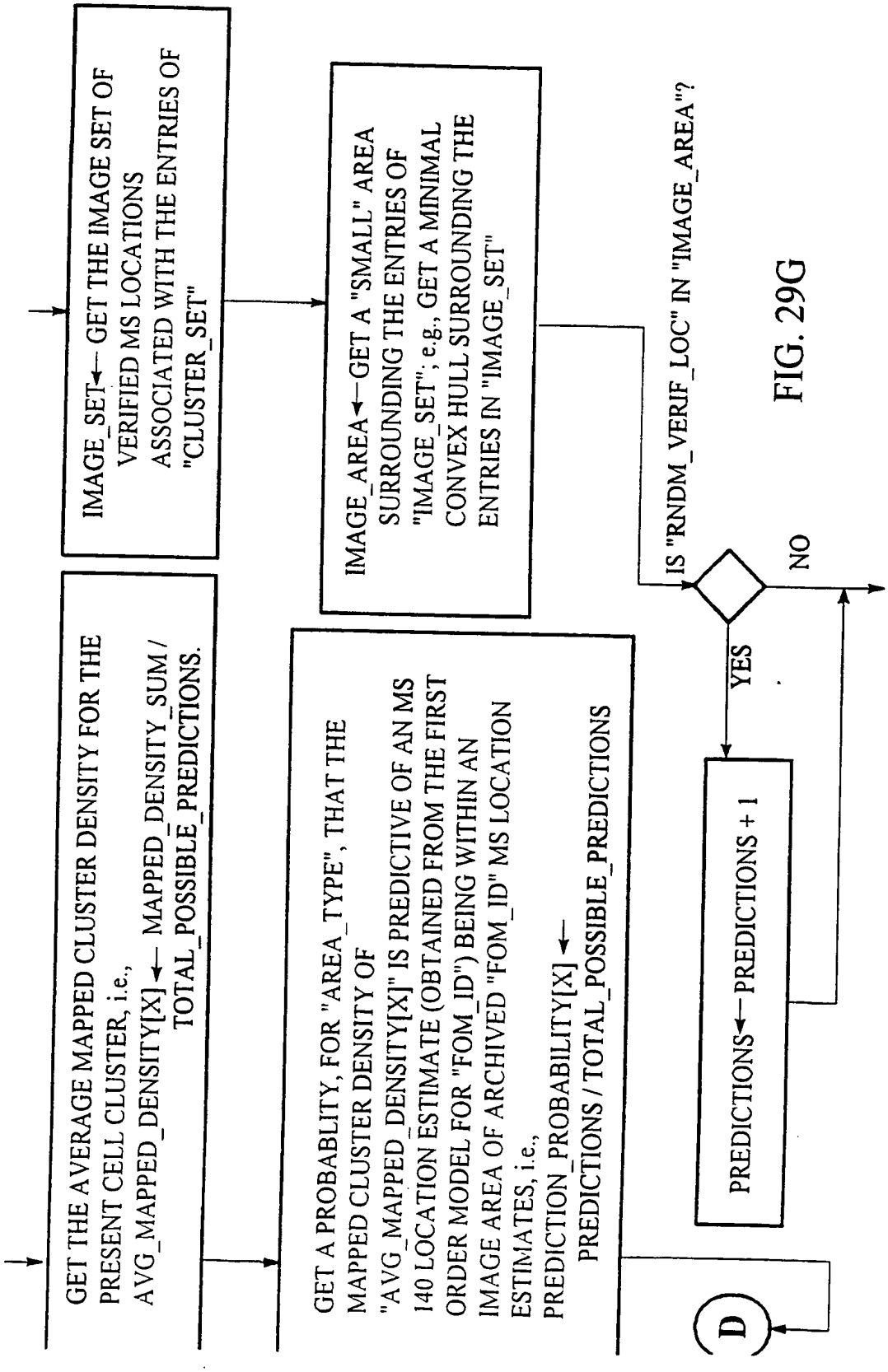
GET THE AVERAGE MAPPED CLUSTER DENSITY FOR THE PRESENT CELL CLUSTER, i.e., AVG_MAPPED_DENSITY[X] ← MAPPED_DENSITY_SUM / TOTAL_POSSIBLE_PREDICTIONS.
IMAGE_SET ← GET THE IMAGE SET OF VERIFIED MS LOCATIONS ASSOCIATED WITH THE ENTRIES OF "CLUSTER_SET"
IMAGE_AREA ← GET A "SMALL" AREA SURROUNDING THE ENTRIES OF "IMAGE_SET"; e.g., GET A MINIMAL CONVEX HULL SURROUNDING THE ENTRIES IN "IMAGE_SET"
GET A PROBABLITY, FOR "AREA_TYPE", THAT THE MAPPED CLUSTER DENSITY OF "AVG_MAPPED_DENSITY[X]" IS PREDICTIVE OF AN MS 140 LOCATION ESTIMATE (OBTAINED FROM THE FIRST ORDER MODEL FOR "FOM_ID") BEING WITHIN AN IMAGE AREA OF ARCHIVED "FOM_ID" MS LOCATION ESTIMATES, i.e., PREDICTION_PROBABILITY[X] ← PREDICTIONS / TOTAL_POSSIBLE_PREDICTIONS
IS "RNDM_VERIF_LOC" IN "IMAGE_AREA"?
YES
NO
PREDICTIONS ← PREDICTIONS + 1
D

FIG. 29G

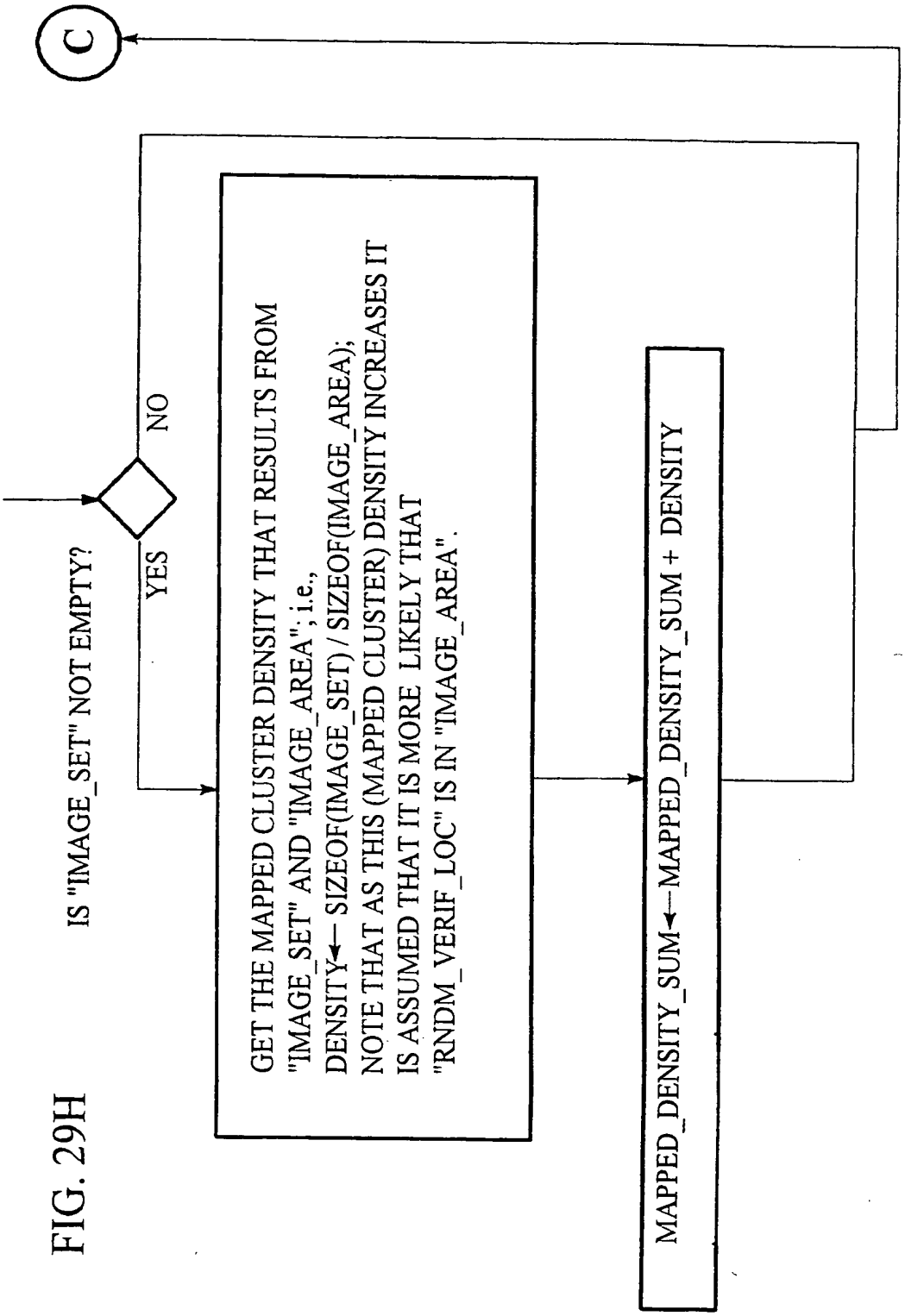
C
IS "IMAGE_SET" NOT EMPTY?
NO
YES
GET THE MAPPED CLUSTER DENSITY THAT RESULTS FROM "IMAGE_SET" AND "IMAGE_AREA"; i.e., DENSITY← SIZEOF(IMAGE_SET) / SIZEOF(IMAGE_AREA); NOTE THAT AS THIS (MAPPED CLUSTER) DENSITY INCREASES IT IS ASSUMED THAT IT IS MORE LIKELY THAT "RNDM_VERIF_LOC" IS IN "IMAGE_AREA".
MAPPED_DENSITY_SUM←MAPPED_DENSITY_SUM + DENSITY

FIG. 29H

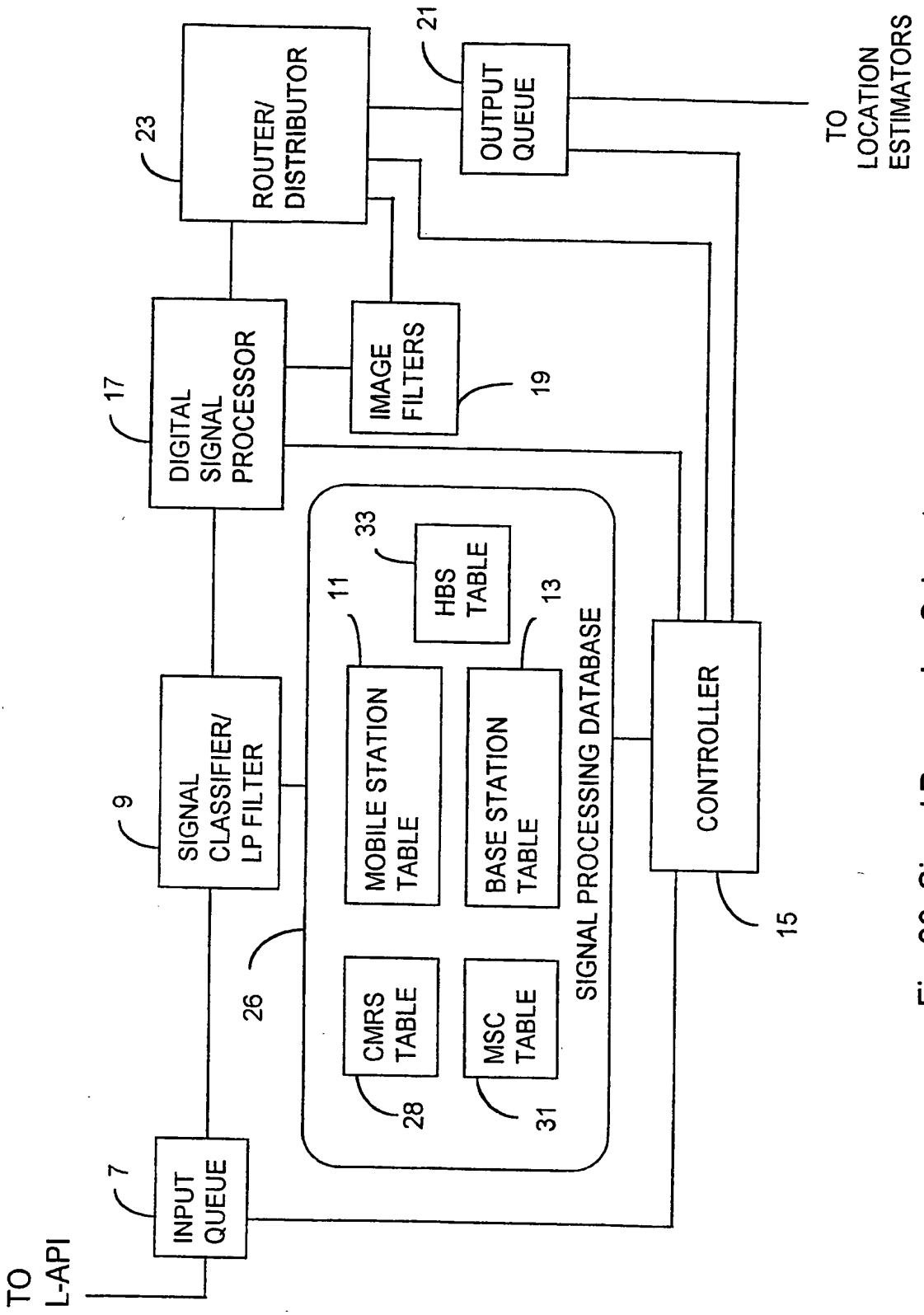

Fig. 30: Signal Processing Subsystem

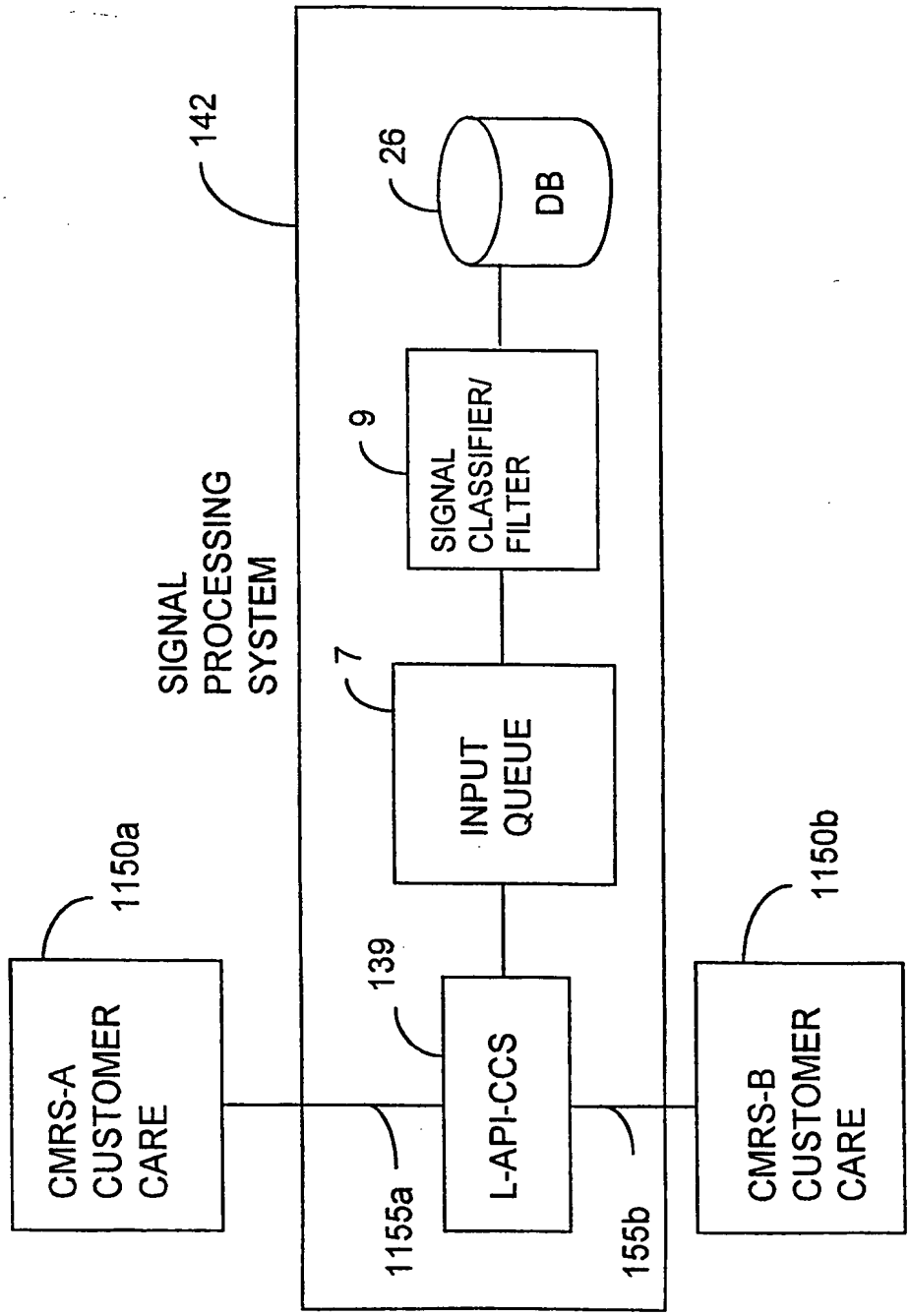

FIG. 31: LOCATION PROVISIONING VIA MULTIPLE CMRS